A STUDY OF THE INDICATORS THAT ARE ASSOCIATED WITH SELF-REPORTED FATIGUE BY OFFICERS OF THE WATCH

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ABSTRACT

Limited research exist examining fatigue and its indicators among seafarers. The purpose of this exploratory research was to determine the influence of occupational, individual, and environmental factors on subjective fatigue among officers of the watch. Data was collected from 21 participants dispatched on vessels in the Canadian offshore sector. Self-reported questionnaire methods (pre-voyage, before watch, and after watch) were employed to collect data on momentary subjective physical and mental fatigue for comparison with occupational, individual, and environmental factors while on a seagoing trip. Mixed multi-level linear model analysis revealed differences across individuals and the factors that influence before watch and after watch perceptions of fatigue. These factors include caffeine consumption, sleep quality perceptions, environmental factors such as noise and motion, and psychosocial work factors. Age was also found to be an interaction factor with some of these variables. Further future research needs to be conducted to explore this analysis tool among more maritime employees.

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List of Symbols, Nomenclature or Abbreviations

ABCD	American, British, Canadian, and Dutch Working Group
aMT6s	Melatonin metabolite 6-sulphatoxymelatonin
CFS	Chadler Fatigue Scale
EOG	Electrooculography
GHQ	General Health Questionnaire
HIC	Human Investigations Committee Memorial University
MMLM	Mixed Multi-Level Linear Model
PMFS	Physical-Mental Fatigue Scale
PFRS	Profile of Fatigue Related Symptoms
OOW	Officer of the Watch
SF-36	MOS Short Form Health Questionnaire
SOFI	Swedish Occupational Fatigue Inventory

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CHAPTER 1 INTRODUCTION

Fatigue is a ubiquitous phenomenon that has been found to be relatively common and linked to reduced performance, injury, and chronic health issues among the general working population (Wadsworth, Allen, McNamara, & Smith, 2008). In recent years, work-related fatigue has garnered great attention in the maritime industry as organizations cope with increased demands and reduced crew sizes. As a construct, fatigue is difficult to define as it includes a number of physical, psychosocial, and behavioural attributes. Gawron, French, & Funke (2001) elaborate on this multi-dimensional concept through explanation that the outcomes from fatigue affects not only performance, physiology, cognition, and emotion, but combines with other states such as stress and boredom. The interactions of these states are apparent when the two prominent types of fatigue are considered: physical and mental. Physical fatigue is a reduction in the ability to perform physical work as a result of previous physical effort (Gawron et al., 2001). Mental fatigue results in reduced performance on tasks that require attention and alertness with memory retrieval (Gawron et al., 2001). Performance has been identified to be impacted by both of these types of fatigue. However, fatigue in general is considered a subjective experience most commonly measured through subjective measures (Fu, LeMone, McDaniel, & Bausler, 2001; Shen, Barber, & Shapiro, 2006).

Fatigue may be defined as "a subjective, unpleasant symptom which incorporates total body feelings ranging from tiredness to exhaustion, creating an unrelenting overall condition which interferes with an individual's ability to function in their normal capacity" (Bridger, Brasher, & Dew, 2010, p.1006). The maritime work environment presents many unique challenges that may further exacerbate these fatigue symptoms.

Employment at sea often requires being offshore for extended periods of time, making the work environment one's place of habitation and leisure 24-hours a day (Louie & Doolen, 2007). Being such a dynamic work environment, unanticipated changes could result in reduced sleep, extended work days, increased workload, poor dietary habits, inconsistent exercise, and social isolation for seafarers. Coinciding with these factors is the added energy requirements associated with working in a moving environment. Increased physiological and biomechanical compensation resulting from consequential motions in typical, unpredictable or harsh weather may limit an individual's ability to perform essential tasks. The American, British, Canadian, and Dutch (ABCD) Working Group on Human Performance at Sea demonstrate that tasks performed as a part of routine daily operations can be impacted by motion induced sickness, interruptions, or fatigue (Figure 1-1; Colwell, 2005).

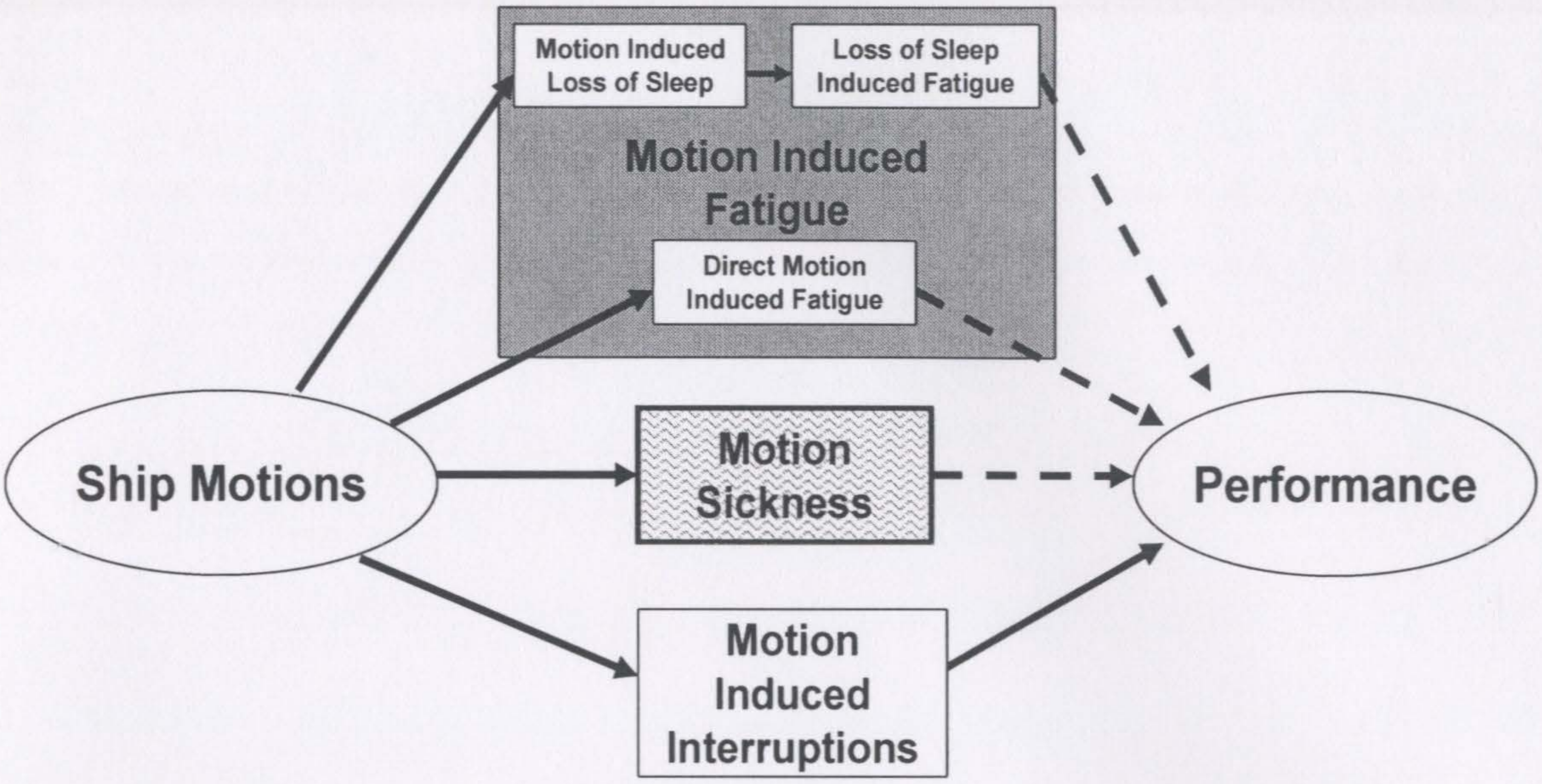

Figure 1-1: How ship motions can affect operator performance. From the ABCD Working Group

When ship motions become sufficient enough to cause an individual to lose postural stability, motion induced interruptions occur. These interruptions result in the temporary abandonment of tasks until balance is restored (Stevens & Parsons, 2002). Consequently, individuals may be placed at an increased risk for overexertion injuries, compromising task performance and individual safety (Matthews, MacKinnon, Albert, Holmes, & Patterson, 2007; Holmes, MacKinnon, Matthews, Albert, & Mills, 2008). Motion sickness (Stevens & Parsons, 2002) and motion induced fatigue (Marais, Basset, Duncan & MacKinnon, 2010) have also been found to negatively affect task performance in seafarers. Motion induced interruptions, fatigue and sickness all have either direct or indirect relationships with overall operator fatigue.

Motion sickness (also referred to as seasickness) is an apparent and unsettling effect of ship motion on the seafarer. Widely studied, seasickness usually occurs when an individual is not adjusted to the motion response of the vessel, resulting in sensory conflict and symptoms of nausea and discomfort (Colwell, 2005; Grech, Horberry, & Koester, 2008). Affiliated with motion sickness, sopite syndrome is a form of motion induced drowsiness specific to seafarers. Symptoms of sopite syndrome include yawning, drowsiness, reluctance to work and disengagement in group activities. Seasickness affects not only the specific individual but other crewmembers as additional tasks and responsibilities are placed on them to ensure the continual and efficient operation of the ship, potentially compromising safety and performance.

Research has suggested that work in a moving environment may be as twice as fatiguing as work in stable surroundings (Wertheim, 1998). Motion induced fatigue can occur either directly or indirectly for an individual. Directly, accelerated feelings of physical fatigue occur as one increases energy expenditure to maintain balance and position in a moving environment (Grech et al., 2008; Marais et al., 2010). Indirectly, continuous sleep interruptions as a consequence of motion can result in accumulated feelings of fatigue (Colwell, 2005). The effects of motion induced fatigue on individual behaviour and performance is important in fatigue comprehension. The question remains if other factors present in the surrounding work environment such as work related demands and individual factors also contribute to seafarer fatigue.

Despite maritime-specific fatigue research beginning in 1950's, limited research on seafarer fatigue and its precursors exist (Grech et al., 2008; Smith, Lane, Bloor, Allen, Burke, & Ellis, 2003). To date, the work of Seafarers International Research Centre (Smith et al., 2003; Wadsworth et al., 2008) is one of the most comprehensive research program to explore the multi-dimensional nature of maritime fatigue. This research program performed a cross-sectional study that covered all sectors of the British seafaring industry to address the lack of research aimed at determining the relationship between fatigue and associated risk factors at sea. The findings from Smith et al. (2003) and Wadsworth et al. (2008) demonstrated the multi-factorial nature of fatigue, including occupational, individual, and environmental factors, emphasizing the need for stakeholders to mitigate these factors as practicable.

Organizational focus should be on minimizing fatigue-related risk, but with continuously advancing technology on vessels and reduced crew numbers, focused is placed on cargo maximization--potentially at the expense of worker health and safety (Calhoun, 2006). The accumulation of fatigue is expected to reduce vigilance and impede abilities to make decisions or take actions. In such a highly complex and automated work environment like a ship's bridge, Officers of the Watch (OOW) can make command and control-related mistakes, which may lead to near misses or catastrophic accidents (Allen, 2009). Concern with maximizing profits has reduced readiness to deal with fatigue in this industry. The effects from fatigue then become a continuous cycle, until a near miss or catastrophic event takes place that momentarily directs public and stakeholder attention to the seriousness of seafarer fatigue.

Numerous anecdotal reports deem fatigue a causal factor in maritime accidents, but due to limited empirical evidence, the exact contribution of worker fatigue in these accidents is difficult to estimate (Wadsworth et al., 2008). Fatigue-related accidents could be categorized a result of "human error", placing the individual at the center of blame. Supported by Bloor, Thomas and Lane (2000), human error should not be used as a catch phrase to insinuate at fault behavior in incidents resulting from commercial pressures, decreased crewing levels, short turnaround times, insufficient training, or extended work hours that could evidently result in fatigue. Using a systemic accident model approach that considers the interrelated elements comprising a system, the interaction of these factors could increase the likelihood for a fatigue related vigilance error (Dekker 2006).

Described by Furnham, 1997 (as cited in Grech et al., 2008) a sociotechnical system model represents, "a set of interrelated elements that functions as a unit for a specific purpose (p.21; Figure 1-2)." In the maritime industry, the sociotechnical model characterizes a holistic systematic approach to human factors, unlike a stepwise or fragmented approach for dealing with relationships among various elements of the system and their influence on performance. The grounding of the Exxon Valdez is an example of how some of these system elements (individual and organizational) interact to contribute to a fatigue related vigilance error.

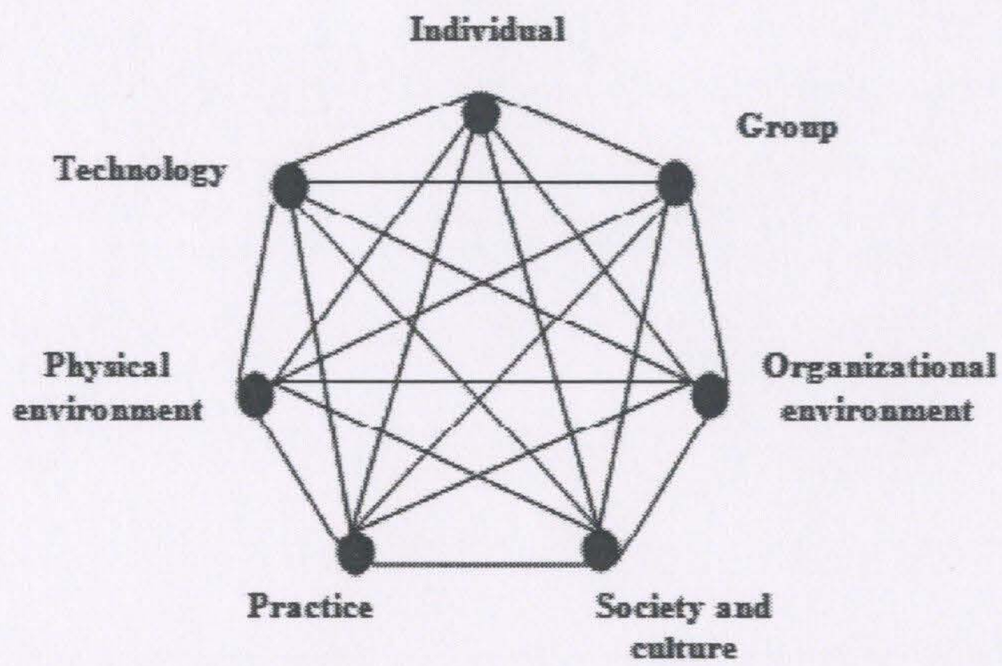

Figure 1-2: Sociotechnical model adapted from Grech et al. (2008)

Recognized as one of the worst environmental and economic oil tanker spills in the United States of America's history, the grounding of the Exxon Valdez is a somber, real life reminder of the implications of fatigue related accidents (Allen, 2009; Williams & Treadaway, 1992). Shortly after midnight on March 24^{th}, 1989, the Valdez struck the Bligh Reef and ran aground in Prince William Sound, Alaska, releasing over 258,000 barrels of oil into the water along 1100 miles of shoreline over the next twenty four hours (Moore, 1992). Human fatigue was among the potential reasons for cause contributing to this accident as the watch keeper had only five or six hours sleep in the previous 24 hours (Folkard & Lombardi, 2006; Hetherington, Flin & Mearns, 2006). The decreased manning levels onboard the vessels were also acknowledged to contribute to increased workload and fatigue.

Reductions in crewing levels have been referenced in the literature to potentially lead to injuries and fatalities as crew members struggle to cope to complete tasks that require more individuals, while dealing with broken sleeping patterns (Bloor et al., 2000).

Moore (1992) also discussed the failure of the Exxon organization to comply with federal statutes pertaining to deck officers working schedules. In hindsight, the events leading to the Exxon Valdez accident could have been prevented with proper individual and organizational management. A critical component in the prevention process is comprehension of the potential subjective contributors to fatigue. A holistic approach to understanding these contributors can lead to stronger conclusions about the effect they have on the individual officer, which can lead to more efficient fatigue mitigation in the maritime industry.

1.1 Statement of the Problem

As the shipping industry continues to prosper, obtaining the seafarers' subjective perception of fatigue factors in their work environment is first step towards better health, safety, and fatigue mitigation in the maritime industry. Smith et al. (2003) observe that when evaluating fatigue as a process, it first begins with identification of fatigue risk factors through subjective perception by participants. The problem with this identification is that while a number of factors may contribute to fatigue, including the watch system, sleeping patterns, motion, and work demands (Lützhöft, Dahlgren, Kircher, Thorslund & Gillberg, 2010; Wadsworth et al., 2008), there is a lack of consensus in terms of the multi-factorial interactions among fatigue indicators. These different findings may be due to the specific context of the research in terms of sampling different shipping vessels, work conditions, and subject demographics (Wadsworth et al, 2008). "Individuals react differently to fatigue…" (Calhoun, 2006, p.9) implying that the numerous factors define a seafarers working context all need to be examined. Lack of conformity among the literature is not an entirely negative issue as it highlights the complexity when studying seafarer fatigue; however, variation makes it difficult to make inferences between studies. Consideration of various work contexts is essential to fatigue comprehension as cross-cultural validity may not be effective for the implementation of fatigue management programs for different geographical regions. Therefore, the current study being exploratory in nature will look to address this problem through a comprehensive evaluation of subjective fatigue factors analyzed at both the individual and group level.

1.2 Research Questions

The study will address the following research questions:

1. Does before watch fatigue perception affect after watch fatigue perception across participants?
2. Does a specific watch reported affect perceptions of fatigue across participants?
3. Is caffeine a coping mechanism used to alleviate symptoms of fatigue?
4. Do poorer ratings of sleep quality obtained prior to watch associate with increased perceptions of fatigue across participants?
5. Do environmental factors such as noise and motion associate with perceptions of fatigue after the watch across participants?
6. Do psychosocial work factors such as perceived work stress and co-worker support associate with perception of after watch perception of fatigue across participants?

7. Do individual factors such as age and experience associate with participant perception of fatigue? Do these individual factors interact with other factors to effect this fatigue perception across participants?

CHAPTER 2 LITERATURE REVIEW

Prior to 1860, there had been essentially no recorded account of fatigue in the medical or scientific literature (Rabinbach, 1990). An article published by George Poore in 1875 distinguished between the general and local, acute and chronic symptoms of the disorder (Rabinbach, 1990). Research on fatigue began to appear in the late 19th century and quickly became a focal point for research, especially in Europe and was related to the industrial revolution. In European society, "fatigue became the permanent nemesis of an industrializing Europe" (Rabinbach, 1990, p. 4). The boundaries of the human body were potentially limiting the progress that could be made in an expanding industrial society. For many, fatigue defined not only the boundary of the working body, but the point beyond which society could not transcend without jeopardizing its own future capacity for labour (Rabinbach, 1990). Fear surrounding human fatigue merged scientists and concerned politicians to work together to apply empirical research with rational principles to devise a solution to the fatigue problem.

In the 21st century, the research community is still looking for a definitive solution to the fatigue dilemma. Compared to the 19th century, when an emerging industrial society was pushing the working body beyond its capabilities, society in the 21st century is reliant on systems that operate 24 hours a day. The social desire for readily available service operations such as restaurants, retail, transportation and entertainment (Konz & Johnson, 2000) has individuals being pushed beyond their abilities in the form of shiftwork and irregular working hours. As service demands require nonstop operations, the efficient transport of goods and services has become essential.

Described as the "original 24 hour society" (Phillips, 2000, p.1), the shipping industry has a significant role in ensuring these needs are met in a timely manner. Despite this sectors efficiency in transport, the critical element that cannot be controlled is the individual seafarer (Desmond & Hancock, 2001). The innate ability of individuals to be diurnal differs with the demands of a 24 hour society, leading to the continuous issue of seafarer fatigue.

Fatigue has been readily identified in the road traffic and aviation sectors as a negative factor affecting task performance for decades (Lützhöft et al., 2010). Only in the last couple of decades has seafarer fatigue and its precursors become identified as a health and safety concern in the maritime industry. In a centuries old industry and with 90% of goods being transported by ship (Allen, 2009), it may be questioned why seafarer fatigue is only now becoming a research priority. Rationale for this neglect may be that aside from public transport operations, the daily activities of seafarers are not seen by the public. Vessels are visible coming in and out of port but the daily operations and its effect on the individual seafarer may not be scrutinized. Public attention is only drawn to this serious issue when a large scale accident takes place that cites fatigue as a causal factor. The traditional view of seafaring may be another reason why fatigue has been under-researched in this industry.

According to Carter (2005, p.63), seafaring is traditionally viewed as a "strong profession, with a custom of service, stoicism and little sympathy for the person who cannot make the grade." Expected to meet high operational demands, if one cannot work due to illness, extra burden is placed on the other crew members, pressuring the fatigued seafarer to continue working alongside his crewmates. Seafarers are also placed in a dynamically changing work environment as vessels may unexpectedly and frequently travel from port to port or remain stationed at sea for extended periods of time. This can pose problems for the researcher interested in studying fatigue among this population. Unanticipated changes in work schedules, shipping routes, or weather can make it costly and timely to access this population. Nonetheless, research on maritime-specific fatigue is a recognized important and growing area of study. The world merchant fleet is comprised of approximately 1.4 million seafarers (International Labour Organization, 2010). Thus, understanding the potential risk-factors that may contribute to fatigue is of huge importance to this industry.

This review of literature will examine the relevant literature pertaining to fatigue and the contributing factors in the maritime industry. The role fatigue in maritime-related accidents will be articulated first as it builds support for the ongoing continuance of fatigue comprehension in industry. Why comprehension of fatigue may be limited or misinterpreted is then presented with theoretical frameworks of fatigue from various disciplines. A discussion on the lack of a holistic definition of fatigue in the maritime industry with identified fatigue risk factors is then presented. Lastly, various methods of fatigue measurement that have been applied in maritime research are discussed.

2.1 Role of Fatigue in Maritime Related Accidents

Employment at sea has one of the highest rates for occupational accidents and injuries (Wadsworth et al., 2008). Coupled with the inherent danger of working in an unpredictable environment, the effects of fatigue can place the responsible seafarer, their co-workers and the safe operation of the ship at increased risk. Disastrous individual, environmental, or economical consequences can occur as a result of compromised safety (Louie & Doolen, 2007). Fatigue has been identified as the largest preventable cause of accidents in general transport operations as 15 to 20% of all accidents are attributed to fatigue (Åkerstedt & Wright, 2009). In maritime accidents, fatigue has been deemed a causal factor in numerous anecdotal reports, but the exact contribution is difficult to approximate due to limited empirical evidence stated in accident reports or through near miss incidents (Wadsworth et al., 2008).

The potential underestimation of fatigue causation in accidents may be due to a lack of empirical evidence accumulated from the accident investigation. The purpose of an accident investigation, which determines the resources utilized including analyses and reporting tools, may not account for fatigue related factors (Raby & Lee, 2001). The purpose of the investigation and chosen tools will determine the amount of information collected. The inexistence of a validated and reliable device for detecting fatigue (e.g., in comparison to taking breath analyzer to determine alcohol levels) further complicates the collection of valid information on the role of fatigue in maritime related accidents. Reyner & Baulk (1998) note that to attribute the role of fatigue to accidents, information on watching keeping patterns, the exact time of incident, watch length, and the duration of the watch keeper's sleep/rest periods for the previous 48 hours should be included. Although it is difficult to conclude that fatigue is a main or contributing factor in any accident, this valuable information can provide insight on fatigue mediation and prevention.

Due to the difficulty in quantifying fatigue, fatigue-related accidents may be underreported. Attempts at quantifying fatigue as a casual factor specifically in maritime accidents has led to less than 10% of accidents being attributed to fatigue, with more recent literature citing around 20% (Grech et al., 2008). In the United Kingdom, between 70-80% of maritime pollution-causing accidents could be either primarily or strongly attributed to fatigue (The Donaldson Report, 1994, cited in Bloor et al., 2000). It is apparent that appropriate procedures should be established to mitigate fatigue to prevent maritime accidents. Advocating for these procedures and understanding the role of fatigue in maritime accidents usually only occurs after a major nautical catastrophe has occurred. For example, fatigue was believed to be a contributing factor to the grounding of the Jambo off the West coast of Scotland in 2003. This grounding obtained enough attention from the industry and research fields for a major accident analysis to take place.

A dry cargo vessel, the Jambo was carrying 3,300 tons of zinc concentrate and its grounding sparked fears of an environmental disaster (Maritime Accident Investigation Branch, 2004). Prompted by this grounding, the Maritime Accident Investigation Branch undertook a study to determine the principal factors leading to maritime accidents and examined whether fatigue was a critical factor in previous accidents. The results published in 2004 consisted of an analysis of 66 accidents involving 75 vessels that were reported to the United Kingdom's Merchant Shipping Regulations between the years 1994-2003. The results revealed:

1/3 of vessel groundings involved a fatigued officer alone on the bridge at night;

2/3 of vessels involved in collisions were not keeping sufficient lookout; and

1/3 of accidents that occurred at night involved a sole watchkeeper.

These statistics attribute fatigue as a causal factor in maritime accidents, especially when there is a sole individual on watch. Statistics such as these place the individual seafarer at the fault for the accident, which has been stressed (Dinges, 1995; cited in Phillips, 2000):

"...it is now possible for a fatigue related vigilance error of a single person working on the night shift and/or without adequate sleep to trigger an industrial accident that can kill thousands of people, damage major proportions of the environment and/or cost billions of dollars." (p.6).

Assigning blame for an accident to one individual is a scapegoat mechanism. Rather than insinuating blame, human error should be viewed as a structural by-product of people attempting to pursue success in resource-constrained, uncertain, imperfect systems (Dekker, 2006). Imperfect systems are highly evident in today's fast pace global shipping market, where there is a shortage of experienced personnel and frequent cost cutting. The accident report of the Herald of Free Enterprise embraces this new view of accident modeling.

The Herald of Free Enterprise was leaving Zeebrugge harbour in Beligium for Drover, England on March 27, 1987 when water began flooding the car deck due to the bow doors being left open (Grech et al., 2008). The vessel proceeded to list to starboard and quickly filled with water, resulting in the vessel capsizing. More than 190 individuals lost their lives. An initial conclusion by the company's management was that human error was to blame for the ferry sinking, as one of the crew members fell asleep in the cabin and left the loading doors open. The report commissioner had a different perception of accident causation.

While the shipboard errors of the crew were acknowledged, the report commissioner also indicated that the underlying or cardinal faults lay higher up in the company: "...the body corporate was infected with the disease of sloppiness" (Grech et al., 2008, p. 129) and it was concluded that knowledge transfer about operational safety needed to be extended beyond the individual. Thus, numerous organizational components comprising a system may contribute to accident causation. Acknowledgement that safety comes from various levels within the organization should be applied to understanding the the etiology of fatigue. To further increase comprehension of fatigue related risk in this industry, the application of fatigue in different theoretical frameworks and conceptual descriptions of fatigue will be discussed next.

2.2 Theoretical Frameworks of Fatigue

Regarded as a complex phenomenon, fatigue has been studied by a variety of disciplines that have established theories recognizing its multi-factorial etiology. These theories have included central and peripheral neurophysiologic mechanisms; physiological, psychological and situational factors; personality and environmental factors; and symptom and activity patterns (Fu et al., 2001). Theoretical frameworks serve as a method for portraying and explaining the fatigue phenomena and its relationships. Each discipline defines fatigue as a construct based on the specific fatigue focus of the field.

Theoretical models of fatigue have been proposed elsewhere focusing on the multi-factorial causes and indicators of fatigue (Fu et al., 2001). For example, physiological models of fatigue focus on the energy expenditure, disturbances of the electrolyte homeostasis or accumulation of metabolites when at work (Åhsberg, Gamberale & Kjellberg, 1997). Biomechanical models consider the loads on the musculoskeletal system during work, providing information on the forces and torques that are generated during this time. Alternatively, psychological models emphasize the important role of motivation and other individual factors in the role of perceived effort and fatigue.

There are few models proposed in maritime related fatigue literature due to the limited research in this area. This inhibits strong model development of the multi-causal factors of fatigue for this industry. Theoretical frameworks are immensely valuable to various disciplines partaking in fatigue related research and provide direction to academia and industry. These frameworks aid in the identification of the multi-dimensional fatigue mechanisms and the design of fatigue management interventions (Fu et al., 2001). The conceptualization of fatigue also develops from these frameworks which has been the subject of much deliberation in the literature.

2.3 Describing Fatigue

The word "fatigue" has long been used in conversation among the general population. Fatigue often refers to symptoms which occur as the result of work or play, in conditions that result in reduced performance assumed to be alleviated by rest, unlike other symptoms or diseases (Tepas & Price, 2001). A "restitutional theory of fatigue" has resulted from this perception of fatigue, one that has evolved by intuition and experience with the premise that fatigue symptoms can be reduced by rest (Tepas & Price, 2001, p.610). Contrary, it is recognized that rest does not always ensure a full recovery in performance. Due to displeasure with the broad concept of fatigue used among the general public, research focused on better describing fatigue has developed. As stated by Tepas & Price (2001) "the results of decades of fatigue research are sometimes confusing, often ignored, and certainly not easy to comprehend" (p.610).

A recommendation was given in the 1920's to abolish fatigue from scientific literature due to its ambiguity in definition and measurement (Carmichael, Kennedy & Mead, 1949; Muscio 1921). As this expulsion has never occurred, a clear conceptualization of fatigue is needed to provide direction for its operationalization in empirical measures. Various descriptions have been proposed based on these outcomes that highlight the dimensions of fatigue including muscular, mental, and general fatigue (Table 2.1).

Table 2.1

Different dimensions of fatigue referenced in the literature

Type of Fatigue	Description	Author
General	Accumulation of all the stresses of the day including the duration and intensity of physical and mental work, time of day the work is performed, and the amount of prior sleep that the individual has received	Gawron et al., 2001
Muscular	Results from heavy physical work and is localized in overstressed muscles	Grech et al., 2008; Shen et al., 2006
Mental	Reduced performance on tasks that require attention and alertness with memory retrieval	Gawron et al., 2001

Fatigue may also be acute or chronic in nature. It has been proposed that acute fatigue is a naturally occurring phenomenon that is alleviated after rest and is identified by reversibility, task specificity, and the functional use of compensation mechanisms such as caffeine (Shen et al., 2006; Wadsworth et al., 2008). Chronic fatigue has been found to be more problematic to the individual as it is irreversible, not task specific and not relieved by compensatory mechanisms (Shen et al., 2006; Wadsworth et al., 2008).

The apparent ubiquitous nature of fatigue has made for difficulty in providing a suitable holistic definition for the construct. Descriptors of fatigue have been put forth in the maritime literature that considers the physical and/or mental aspects fatigue (Table 2.2).

Table 2.2

Fatigue descriptors in the maritime literature

Description	Author
Generally thought of as a subjective sensation on a continuum with behavioural, emotional and cognitive components	Wadsworth et al. (2008)
Considered to be a generic term of which sleepiness is one of the major subcomponents	Lützhöft et al. (2010)
Refers to feelings of tiredness and bodily discomfort associated with prolonged activity	Leung, Chan, Ng, & Wong (2006)

Commonly cited in the maritime literature is a description from the International Maritime Organization's (IMO, 2001; as cited in Gander, Berg & Signal (2008); Lützhöft et al., 2010):

> "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, p.4)

Considering the different physical, mental or emotional components that can contribute to detrimental performances, there is great relevance to this description when placed in the context of the maritime industry. A reduction in strength or balance could result in a slip on the deck or the mishandling of cargo which could lead to personal injury. Impairment in one's decision making abilities or reaction time may reduce the likelihood in noticing or correcting a technical error. As a result, a collision with another vessel or grounding, increasing the risk of environmental or economical loss could occur.

Thus, it is evident that fatigue resulting from either one of these components (e.g. physical, mental, or emotional) could impair an individual's ability to efficiently respond to an unexpected event or emergency situation.

Another suitable description of fatigue must be provided if performance outcomes are not measured in the research. From this perspective, fatigue may be defined as "a subjective, unpleasant symptom which incorporates total body feelings ranging from tiredness to exhaustion, creating an unrelenting overall condition which interferes with an individual's ability to function in their normal capacity" (Aaronson, Teel, Cassmeyer, et al.,1999, p. 46; Bridger et al., 2010, p.1006). This description emphasizes the subjective aspect of fatigue and how it can differ among individuals.

2.4 Maritime Related Fatigue Risk Factors: Overview

The Fatigue Offshore Study from the Seafarers Research Institute (Smith et al., 2003; Wadsworth et al., 2008) is a well known study to extensively explore the multi-dimensional nature of maritime fatigue. Multiple fatigue symptoms were associated with occupational and environmental factors specific to seafaring (Wadsworth et al., 2008). Participant reports of both acute and chronic fatigue resulted in the identification of the following risk factors: high work stress, job demands, shorter tour length, poor sleep quality, younger age, lack of support, physical hazards, sleep disturbance and smoking. For acute fatigue only, the following risk factors were found to be associated: environmental factors, switching from work at sea to port, extended shift length, poorer job security, changing work hours and working 12-hour days.

The findings of this study demonstrate the multi-factorial nature of fatigue consisting of individual (age, smoking and sleeping patterns), psychosocial (job security, support and work stress) and work environment (shift length and physical hazards) factors contributing to subjective reports of fatigue.

There is a lack of consensus in terms of the multi-factorial interactions among fatigue indicators. Leung, Chan, Ng, & Wong (2006) identified age, experience, and perceived voyage difficulty to contribute to an officer's perceived fatigue. Inconsistent sleep times and lack of sleep were identified by Louie and Doolen (2007) to contribute to the fatigue of the person standing watch. Yet, unlike Leung et al. (2006) perceived fatigue levels were not found to vary as a function of watch schedule, age, or experience. This lack of association may be due to the specific context of samples in terms of differing shipping vessels, work conditions, subject demographics and fatigue factor variables considered in the research (Wadsworth et al, 2008). Of these variables of interest, the watch schedule and sleeping patterns of seafarers are some of the most identified fatigue contributors in this industry.

2.4.1 Maritime Watch Schedules and Sleep

Sleep is viewed as a problem among individuals working irregular hours whether employed on land or sea (Eriksen, Gillberg & Vestergren, 2006; Rosa, 2001; Rutenfranz, Plett, Knauth et al., 1988). Sleep deprivation arising from irregular work hours have been known to contribute to workplace accidents and incidents (Ferguson, Lamond, Kandelaars, Jay & Dawson, 2008). Ferguson et al. (2008) observed that seafarers have consistently reported struggling to obtain adequate restorative sleep which is important for rejuvenation and alertness. Restorative sleep has four components including duration, continuity, quality and time of day which are all required in order for sleep to be restorative (Calhoun, 2006). An individual's sleeping quarters determines their ability to obtain three of the four components of restorative sleep (quantity, continuity, and quality). Quantity and time of day are influenced by the watch schedules, individual habits and operational requirements (Calhoun, 2006).

A rapidly rotating shift schedule, known as sea watch systems, is employed by the shipping industry. The maritime sea watch system reduces sleep by influencing one's circadian rhythm, which is the physiological and psychological changes that occur throughout a twenty four hour cycle (Calhoun, 2006), potentially leading to increased feelings of fatigue. These rhythms are a set of physiological events including body temperature, heart rate, blood pressure, and hormone excretion with the circadian pacemaker being located in the suprachiasmatic nucleus that fluctuate on a 24 hour basis. The circadian rhythm is controlled within the body by a self-sustained pacemaker or internal clock that runs are a daily cycle and is reinforced by human social behaviour (Kroemer, Kroemer, & Kroemer-Elbert, 2001). In addition to changes in the circadian cycle, other factors that may affect alertness and influence fatigue include the workload during the watch, the number of hours on watch, the consecutive hours awake and the watch station environment (Calhoun, 2006).

The maritime watch system involves a staggered work-rest scheduling period usually consisting of either a) six hours at work (6-on) and six hours of rest (6-off) or b) four hours of work (4-on) and eight hours of rest (8-off) (Appendix A). The maritime sea watch system is also a unique category of shift work with the added complication that long voyages frequently involve rough weather, time zone change, and potential rapid changes in day length (Arendt et al., 2006). Regulations are in place (Marine Personnel Regulations, Canada Shipping Act, 2012, SOR 2007-115) to keep watch standing hours controlled which often requires written individual records. However, these records are often under recorded as officers work overtime to meet the demand of operational commitments. As illustrated in Appendix A, officers on the 6-on, 6-off watch system may not receive sufficient recuperative rest in comparison to the 4-on, 8-off watch system.

Comparable findings are present among research examining either the watch schedule or sleeping patterns. Comparison between the two watch systems on sleep identified that seafarers working the 6-on, 6-off shift may have shorter sleep episodes before watch compared to the 4-on, 8-off watch (Härmä, Partinen, Repo, Sorsa & Siivonen, 2008; Lützhöft et al., 2010). Implementation of a variation of the 4-on, 8-off watch system observed that individuals on the 6-on, 6-off watch had shorter sleep episodes than those working the modified 4-on, rest period, 8-on watch (Donderi, Smiley & Kawaja, 1995). Among this research, there was essentially no difference in the total mean hours of sleep reported between the watch systems (Donderi, et al., 1995; Lützhöft et al., 2010). Nonetheless, individuals on the 6-on, 6-off watch were more likely to report higher levels of subjective sleepiness at night (Lützhöft et al., 2010) between 00:00 and 06:00 hours (Eriksen et al., 2006; Härmä et al., 2008; Lützhöft et al., 2010).

During the time period between 0000 and 0600 hours, accident frequency is increased between two vessels (Lützhöft et al., 2010). This finding may be supported by the Maritime Accident Investigation Branch Bridge Watchkeeping Study (2004) which observed that during the watch keeping hours of 0000 to 0600, fatigue was considered a factor among 9 out of 11 grounded vessels. Safety issues during this night shift could result from reduced sleep quality and alertness during the second watch of the day (Arendt, Middleton, Williams, Francis & Luke, 2006; Sanquist, Raby, Forsythe & Caravalhais, 1997), highlighting that night workers and individuals working a 6-on, 6-off shift may have more sleep problems or shorter sleep episodes than day workers or other watch schedules. Concrete conclusions regarding which watch system is optimal to the seafarer cannot be established until further comparisons of these watch systems are conducted. These findings demonstrate that working patterns at sea may be associated with disrupted or fragmented sleeping patterns.

2.4.2 Age

Findings related to age as an indicator of fatigue in the maritime literature contradicts other industry studies of shift work and age, suggesting that age may not be a strong indicator of subjective fatigue. One may assume that older seafarers would experience greater fatigue. Yet, younger seafarers have reported greater levels in comparison (Leung et al., 2006; Wadsworth, 2008). Young seafarers may struggle with coping with job demands and work schedules early on in their careers compared to experienced seafarers (Jezewska, Leszcsynska and Jaremin, 2006). This could lead to increased perceptions of fatigue. The inverse relationship between age and fatigue in this industry could also be explained through a "survivor" effect. In the maritime industry, a survivor effect can occur for differing reasons such as individuals who struggle to cope with work at sea leave the occupation. Additionally, older seafarers may have developed strategies to successfully cope with the working demands onboard the vessel (Bridger et al., 2010). Bridger et al. (2010) explored this concept and found no difference in age and work-related fatigue. Rather, fatigue was found to accumulate among individuals with high work demands, potentially supporting the need for management interventions.

2.4.3 Seafarer Health

Seafarers have been characterised for engaging in numerous unhealthy behaviours. A survey of 1806 Australian seafarers revealed that compared to the general public, seafarers consumed more alcohol and smoked more, exercised less and consumed more sugar and fat (Bloor et al., 2000). It was found that United Kingdom Seafarers had high mortality rates for cancer of the oral cavity, pharynx, liver, larynx, cirrhosis, pancreatitis and other "alcohol related diseases" (Bloor et al., 2000). Yet, health surveys of seafarers often show lower levels of morbidity than surveys of general populations (Bloor et al., 2000). These lower morbidity levels may be attributed to a healthy worker effect in this industry- a mandatory periodical medical exam that results in unhealthy individuals leaving the maritime workforce or are prevents these individuals from entering it (Bridger et al., 2010). Another potential reason for these lower morbidity levels among seafarers could be from a lack of coverage in their health care plan. Due to insufficient health plan and Workers Compensation coverage, workers cannot afford to take sickness or lost works days.

Despite potential lower morbidity levels, there is evidence that maritime workers are at risk for physical and mental health problems. For example, shift work in general has been found to contribute to gastrointestinal disorders which may result from food selection and choices (Harrington, 2001). Making good nutritional choices can be difficult to control depending on the watch one works and also the food selection made available onboard. The galley may be closed during the night or dependent on the watch schedule; individuals may have to eat at irregular hours as they missed the scheduled eating periods with their rest periods. Night workers have also the most frequent complaints of dyspepsia, heartburn, abdominal pains, and flatulence (Harrington, 2001). Other factors such as lifestyle and family history need to be considered when accounting for these complaints and, specifically for seafarers, the vessel they are employed on.

A seafarer's workplace also serves as their place of habituation twenty four hours a day for extended periods of a time (Louie & Doolen, 2007) The health and living conditions onboard are ultimately determined by the working conditions put in place by the organization for whom the seafarer work. These working conditions can impact a seafarer's mental health. With the acknowledgement of decreased crewing levels comes added stress from increased competition within industry and feelings of a lack of job security; leading to increased levels of stress (Bloor et al., 2000). With increasing multilingual crews, mental health issues can arise as individuals work without a common language and struggle to communicate (Bloor et al., 2000). Feelings of isolation are prevalent in this industry as contemporary crews face long hours, lonely watches, and individual tasking (Bloor et al., 2000). Comradeship and social capital is subsequently diminished on the vessel with implications for crew mental health. This social isolation could potentially be reduced through rest breaks during the watch that would allow for mental breaks from the task and the opportunity to socialize with other crew members.

2.4.4 Breaks and Fatigue Countermeasures

The literature supports the necessity of rest breaks during the watch as daily output can increase despite a slight decrease in actual working hours (Grech et al., 2008). There are variations in what constitutes a break including: regulated breaks such as lunch or coffee breaks that are often determined by ship operations or the employer; implicit breaks such as alternating between tasks to alleviate potential physical and mental demands from the current task and micro-breaks that are short breaks where an individual will periodically stop their work. These breaks can have positive benefits (Grech et al., 2008). Younger officers can contemplate skills or techniques just learned, eyestrain from staring at navigational systems can be reduced, and there can be recovery from intensive physical and mental work (Grech et al., 2008). These breaks during the watch may also alleviate the symptoms of fatigue while individuals are engaged in a long watch. Officers may also use other measures to counteract fatigue symptoms including strategic napping and caffeine consumption (Grech et al., 2008).

Napping during the watch has been researched in the maritime sector using pilots on the Great Barrier Reef as subjects. Ferguson et al. (2008) found that opportunistic napping during the watch appeared to slow sleep debt accumulation and the appearance of fatigue symptoms on extended pilotages. Further research needs to be conducted, but a brief uninterrupted nap during the watch may alleviate symptoms of fatigue.

Caffeine is one of the most chosen countermeasures of fatigue and sleepiness by shift workers (Åkerstedt & Wright, 2009). A decrease in night time sleepiness and improved performance from caffeine was found in laboratory studies (Åkerstedt & Wright, 2009). These improvements may be greater if caffeine is consumed prior to the onset of sleepiness to oppose it effects (Åkerstedt & Wright, 2009). Consumption wise, Health Canada (2011) recommends that adults may consume up to 400 mg/day of caffeine (approximately three eight ounce cups of brewed coffee per day). Along with keeping individuals awake after the watch and hindering their sleep, overconsumption can lead to nausea, headaches, irritability, increased heart rate and blood pressure, dehydration and nervousness (Health Canada, 2011).

2.4.5 Ergonomic Hazards

Seafarers are constantly exposed to physical hazards within their work environment that may disrupt sleep, induce fatigue and intensify its effects. The shortfalls of the physical environment, including excessive noise, fluctuating temperatures, and living in confined spaces with a lack of privacy, can result in a negative influence on the crew (Grech et al., 2008).

2.4.5.1 Noise

Shipboard noise can have numerous physiological and physical effects that may increase fatigue (Calhoun, 2006). Loss of hearing can be permanent or temporary in nature, with damage occurring to the sensory hairs of the inner ear. A permanent threshold shift of hearing loss is irreversible and develops after extended exposure to noise (Grech et al., 2008). A temporary threshold shift has hearing restored after a period of non-exposure to the noise. Unanticipated irregular noise is more disruptive than continuous noise, and high-pitched noise is often more distracting than low-pitched noise (Grech et al., 2008).

Shipboard noise comes from many sources including the engines, generators, propellers, manoeuvring devices, auxiliary systems, cargo handling, and mooring equipment (Calhoun, 2006; Grech et al., 2008). The living quarters of individuals may sometimes exceed 60 dB, which can affect hearing, alertness and mental health (Bloor et al., 2000). A consequence of the effects of noise, in addition to impairment in hearing, includes communication interferences, performance decrements, stress, and sleep disruption. Noise as a stressor can result in communication problems with other crew members, vital to good bridge resource management and safe ship operation. It can also mask other important signals such as alerts and warnings (Grech et al., 2008).

Distractions stemming from noise can interfere with task performance which can be disastrous when carrying out a task such as manoeuvring the ship or unloading cargo. Even at lower levels of noise, the natural "fight or flight" response occurs as the body interprets noise as an imminent threat or danger (Calhoun, 2006). This includes increases in blood pressure, heart rate and breathing rate, an accelerated metabolism, and low-level muscular tensions.

This fight or flight response can continue to occur even while one is sleeping if noise is still present in the environment, resulting in disruption of an individual's daily routine. Continuous noise pollution can delay the onset of sleep, increasing the number of wakings during the sleep period and reduce the overall amount and quality of sleep (Calhoun, 2006; Grech et al., 2008). Obtaining sufficient rest is already an issue in the maritime industry. The effects of noise can further amplify this problem and result in fatigue, thus influencing officer performance.

2.4.5.2 Temperature

The effects of temperature may be minimal when working on the bridge if it is comfortably regulated with proper ventilation and temperature control systems. Comfortable ranges of temperature are usually between 21 and 24 degrees Celsius (ºC). These comfort levels may be influenced by individual regulatory control mechanisms, perceptions of comfort, the type of clothing worn, the amount of physical work carried out and the time of day or year (Grech et al., 2008).

Research has demonstrated a link between comfort and contentment onboard vessels (Grech et al., 2008). The shipboard accommodations are an individual's living quarters for an extended period of time. Aside from influencing job performance or comfort, accommodations can influence the recruitment and retention of seafarers. Already affected by crew shortages, the inability to retain seagoing personnel can negatively affect those on board as they try to meet the operational demands.

Accommodations can also further influence fatigue if they do not allow for restorative sleep to occur. This can be influenced through the presence of another individual in a cabin affecting personal space, the location of the cabin relative to noisy equipment, and the ability to block out light for those who work night watches.

These ergonomic factors can not only increase the likelihood of injury, but influence individual health and well-being. Identification of these physical hazards in the work environment and their potential interaction with officer fatigue can lead to the implementation of appropriate mitigation measures. This can lead to improved individual performance, a reduction in near misses or accidents and retention of crew. To consider all of these factors, an appropriate measure of fatigue and the characteristics of the work environment need to be accounted. Discussed next, this has been a challenge in the maritime industry.

2.5 Measurements of Fatigue

Various methods are used to measure fatigue in the maritime sector as "there is no direct way of measuring fatigue" (Grech et al., 2008, p. 164). Measurement of fatigue indicators can be objective or subjective in nature.

2.5.1 Objective Fatigue Measures

Objective measures are usually made in relation to physiological parameters and include specialized psychological tasks, physiological monitoring devices and circadian rhythm markers. Reaction time tests include the a) variable fore-period reaction time test, b) the focused attention task and c) the categorical search task (Smith et al., 2003). The variable fore-period simple reaction time test occurs when a task box appears in the centre of the screen and at varying intervals a target square appears in the centre of the box.

Average reaction times are then calculated for the minute and for the task overall. The focused attention task requires participants to react by pressing the same letter as marked in the response box as quickly as possible, with distracters present on either side of the letter. The focused attention task and categorical search tasks are similar through their measurement of mean reaction time, momentary lapses of attention, and the speed of encoding new information (Smith et al., 2003).

The categorical search task differs in that the target letter, either an A or B may appear on the centre or the far left or right of the screen with or without distracters present. During these tests either tasks or target letters appear in the centre or one of two locations at the bottom of the screen respectively. Unlike the focused attention task, the categorical search task also measures reaction times for compatible and incompatible responses and the effects of spatial uncertainty.

Actigraphs are devices that are worn on the wrist and measure acceleration. Data obtained from actigraphs display activity/inactivity measures that may be used to estimate sleep wake patterns of participants (Ancoli-Israel , Cole, Alessi, Chambers, Moorcroft & Pollak, 2003). Electrooculography (EOG) is the recording of eye movements that are used as a measurement of sleepiness when considering blink duration and the number of long closure blinks (Lützhöft et al., 2010). Misalignment the circadian system has been found in the literature to contribute to mariner fatigue (Arendt et al., 2006; Ferguson et al., 2008; Rutenfranz et al., 1988; Sanquist et al., 1997). Physiologically, melatonin metabolite 6-sulphatoxymelatonin (aMT6s) in urine samples is utilized as a marker of circadian rhythm timing (Arendt et al., 2006).

Objective measures can provide insight into performance measures that may be affected by fatigue. From a methodological perspective, these measures can be difficult to use in maritime research. They can be costly and for large scale studies and not practical to give to a large number of participants based on funding constraints. They may also be impractical as devices such as the EOG may be detrimental to an individual's work routine and also have a lot of noise interference from the ship's motion, resulting in a loss of valuable data. They may also be difficult to measure directly as a researcher may need to be present onboard to collect data and aid in setup. Unanticipated changes in vessel scheduling that affects a researchers ability to board the vessel could result in missed data.

Despite these limitations, objective measures are useful when used in conjunction with subjective measures to determine if perceptions of fatigue correlate with valid objective markers (Lützhöft et al., 2010). Maritime fatigue research would benefit from the use of both objective and subjective measures as a strong correlation is often found among objective and subjective fatigue measures. Because a vital aspect to understanding fatigue as a phenomenon is based on an individual's subjective perception of fatigue, the sole utilization of objective measures for indicators of fatigue is often considered inappropriate (Fu et al., 2001). Therefore, objective measures may not sufficiently represent an individual's perception of fatigue, making the use of subjective measures critical in fatigue research (Fu et al., 2001).

2.5.2 Subjective Measures of Fatigue

Self-report scales and questionnaires are commonly employed to subjectively evaluate fatigue (Eriksen et al, 2006; Härmä et al. 2008; Louie & Doolen, 2007; Lützhöft et al., 2010; Wadsworth et al., 2008) and there are over 30 scales developed for measuring fatigue (Shen et al., 2006). Many authors in the maritime related literature used research-developed questionnaires (Arendt et al., 2006; Leung et al., 2006; Louie & Doolen 2007; Rutenfranz et al., 1988) rather than standardized scales. While designed for a specific sample and setting, a limitation of unstandardized measures is that they may lack validity and reliability, reducing the rigour of the research.

Validated scales referenced within the literature to subjectively measure fatigue or sleepiness include the Swedish Occupational Fatigue Inventory (SOFI; Leung et al., 2006), the Profile of Fatigue-Related Symptoms (PFRS; Wadsworth et al., 2008), Karolinska Sleepiness Scale (Eriksen et al, 2006; Härmä et al. 2008; Lützhöft et al., 2010), Karolinska Sleep Diary (Eriksen et al, 2006), and the Skogby Excessive Daytime Sleepiness Index (Härmä et al., 2008). Limitations of these questionnaires are present within the maritime setting as they may not account for the different dimensions of fatigue or a seafarer's specific work context.

The PFRS was developed for individuals with chronic fatigue related illness (Ray, Weir, Phillips & Cullen, 1992). Invaluable as a clinical diagnostic tool, the PFRS was designed to operationalize the concept of chronic fatigue syndrome which may decrease its content validity as a measure of fatigue indicators reported by seafarers. Noticeably, subjective measurements of sleepiness are often utilized as there is a current lack of standardized methods to quantitatively measure fatigue among seafarers (Lützhöft et al., 2010). Use of these scales is problematic considering that sleepiness is but one dimension of fatigue and lacks validity in terms of focusing on fatigue as an entity, detracting from thoroughly understanding the various fatigue factors and their potential implications on seafarers. It is not feasible to assume that such a complex construct as fatigue can be reliably measured through a single or simple measurement. However, discussion towards a subjective measurement of fatigue that accounts for the seafarers specific work context needs to begin that can be used for application in the seafarers natural work environment.

2.6 Conclusion

Maritime related fatigue research has progressed in recent decades; emphasizing the importance of this research area and its implications for seafarer's health and safety. Given that fatigue is considered a very intangible concept, there are innate difficulties surrounding maritime related research. It is also apparent that there are differences in the maritime fatigue literature due to the methodological issues and factors previously discussed.

Continuous evolvement in this research area requires the understanding and exploring of the seafarers unique working context, calling for more studies on the specific indicators of fatigue within seafarers. Increased comprehension of these indicators may lead in the development of more standardized fatigue measurements within this work population, increasing cohesion in this research area. While still accounting for specific work contexts, a unified approach to researching seafarer fatigue could have important global implications within academia, various industry stakeholders, and policy makers who need to collaborate in order to develop a rigorous yet efficient measure of fatigue within this population.

This multi-disciplinary approach may lead to a stronger comprehension of maritime related fatigue and its potential risk which can be used to optimize human performance within this industry. Fatigue mitigation among seafarers is crucial as the shipping industry continues to be relied on for the transportation of goods and services.

CHAPTER 3 METHODS

3.1 Introduction

Limited research has been completed examining the indicators of subjective fatigue of maritime workers. The Cardiff Research Program (Smith et al., 2003) was one of the first major projects that demonstrated the numerous factors that may contribute to fatigue within the maritime industry. The current study used a quantitative, time-series research design using a diary questionnaire. The diary questionnaire protocol allowed for an empirical research approach to investigate the interaction of subjective fatigue and its potential contributing indicators. In this protocol, diaries were completed while at sea and accounted for the occupational, individual, and environmental factors that may contribute to individual perceived momentary fatigue before and after the watch. The following sections will discuss the participants in the research, the data collection protocol, descriptions of the data to be analyzed (variables and measures) and the data analysis.

3.2 Participants

The sample for this study consisted of Officers of the Watch (OOW) from private or public shipping sectors. Officers of the watch serve as the Master's representative and are accountable for the safe navigation of the vessel. Officers of the watch were purposefully chosen for participation as they are required to perform or supervise various tasks including: navigational watches; maintaining the operational demands and safety of the crew; cargo handling, unanticipated repairs and voyage delays; human resource management; emergency practice drills and sustaining regulatory compliance (Phillips, 2000). It can be quite challenging for the individual officer to sustain vigilance with these demands placed on them in such an unpredictable work environment. Twenty-one OOW were recruited through e-mail, telephone, or through one-on-one meetings. Officers in this study could be of any ranking and participation of both sexes was encouraged. The exclusion of other officers (e.g., chief engineers) was due to their work duties not directly involving navigation. The researcher either met with participants face-to- face or through telephone conversation to discuss the research protocol with participants. Participation was voluntary and the experimental protocol was approved by Memorial University's Human Investigation Committee (HIC).

3.3 Data Collection and Questionnaire Selection

Data collection took place from February 2011 to September, 2011 on Canadian vessels that were selected in conjunction with company support and individual Officer's willingness to participate. Data was collected during the duration of various seagoing trips with a prospective average of 1.7 visits to port per trip (*SD*=1.74). The data collection tools were adapted from the second phase of Seafarer Fatigue: The Cardiff Research Programme study (Smith et al., 2003). Smith et al. (2003) reported that analysis of the content within the survey revealed that it provides a good measure of job characteristics that may relate to fatigue and also takes into consideration the unique seafaring work context, vital to understanding the indicators of fatigue. Part of the discrepancy in identifying fatigue indicators within marine fatigue related research is the lack of a cross-culturally valid standardized measurement tool for language comprehension. Therefore, the current research attempted to adapt these questionnaires to determine if they would be suitable for international seafaring use.

Much consultation took place in adapting the questionnaires for application in the current research. Stakeholders in industry, academia, and professionals employed in industry all had input to the content analysis of the questionnaire. Cultural context first had to be accounted for as questions may be interpreted differently in the United Kingdom than Canada. While trying to keep as much of the original questionnaire items as possible, participant compliance were a concern due to questionnaire length and therefore only variables of interest were included to improve completion compliance during the voyages. Participants were required to complete self-administered subjective questionnaires including (a) "pre-voyage questionnaire" prior to a seagoing trip (Appendix B), and (b) two diaries referred to as the "before watch questionnaire" (Appendix C) and "after watch questionnaire" (Appendix D) to coincide with their respective time for completion before and after each watch while at sea or in port. These scheduled periods for questionnaire completion were chosen to not interfere or interrupt work activities that would endanger the safe operation of the vessel.

3.4 Protocol (Variables and Measures)

The research package included a letter explaining the nature and purpose of the research, a letter of consent and the pre-voyage questionnaire and multiple copies of the before and after watch diary questionnaire. The multiple copies of before and after watch diaries were dependent on the length of a participant's seagoing trip and booklets were designed to include 14, 28, 45 and 60 days of data collection. The pre-voyage subjective questionnaire was completed by participant prior to leaving for the seagoing trip and contained 134 items, taking approximately 25 minutes to complete. Completion of this questionnaire was required only once and it was constructed to consider various aspects of participant's work and personal life including individual demographics, nature of the individual's job, sleep behaviours, health and lifestyle behaviours, health outcomes and fatigue. Once the participant boarded the vessel to go to work, each was instructed to complete a self-administered twice daily before and after watch diary questionnaire booklets for the full duration of the work trip.

3.4.1 Fatigue Measurement

Fatigue in this study is defined as a "subjective experience of unpleasant symptoms that includes entire bodying feelings such as tiredness and exhaustion" (Bridger et al., 2010, p. 1006). These bodily feelings may create a condition that disrupts one's ability to normally function. Fatigue was assessed by participants through two scales. First, a six item fatigue scale (adapted from Smith et al., 2003) asked participants to rate the extent to which they experienced different symptoms of fatigue while at sea. Symptoms included confusion, tiredness, poor sleep quality, depression, tension and loss of concentration. Responses were taken on a 5-point Likert Scale from 1-5 (1= *very much* and 5 = *not at all*; Appendix B). These symptoms are descriptive in nature and therefore the validity or reliability of these questions was not reported in the study. A second measurement of fatigue, the physical-mental fatigue scale was employed as a method to momentarily assess fatigue.

The Profile of Fatigue Related Symptoms scale (PFRS; Ray et al., 1992) was utilized by Smith et al. (2003) to measure subjective fatigue in participants. The current study replaced this scale with an adaptation of Pietrowsky and Lahl's (2008) Physical-Mental Fatigue Scale (PMFS) in order assess physical and mental indicators of fatigue in short intervals (such as hours). The decision to replace to the fatigue measurement tool was based on the (a) need for a momentary assessment of fatigue rather than a scale that measures chronic fatigue; (b) need to measure both the physical and mental aspects of fatigue; (c) selection of scale that is more suitable to repeated measures; and (d) selection of a shorter scale that participants would not be apprehensive to complete on a daily bases and uses plain language. The PFRS asks about fatigue-like symptoms within the last week whereas the PMFS is a reliable scale in terms of assessing general feelings to reflect momentary physical and mental fatigue. The PMFS is a relatively new scale with limited reliability research completed on it. However, the PMFS is adapted from The Chadler Fatigue Scale (CFS) which has reported Cronbach Alpha values between 0.88 and 0.90 (Shahid, Shen & Shapiro 2010).

The original version of the PMFS is compromised of eight items indicating physical fatigue and eight items indicating mental fatigue, with agreement of each item rated on a 4-point Likert Scale. Six of the PMFS items were removed as these items were already addressed within other sections of the questionnaire and to also increase participant compliance and reduce participant burden. Specific items found within each fatigue subscale are found in Table 3.1. Participants were asked to rate their present perception of physical and mental fatigue on a 5-point Likert Scale (1 = *very much*, 5 =

not at all), rather than the 4 point Likert Scale that was initially used. The changing of the Likert Scale not only increased its reliability, but also allowed participants to answer if they were only experiencing moderate symptoms rather than being forced to answer in one particular direction because the option was not available. These items were summated and reversed so that higher scores would indicate greater fatigue symptoms reported. Any missing variables were inputted as "neutral." These changes did not affect the psychometrics of the scale as the PMFS was designed as a momentary assessment rather than a standardized scale.

Table 3. 1

Items of the adapted version of PMFS (Pietrowsky & Lahl, 2008)

Mental Demand Variables	Physical Demand Variables
My concentration is very bad	I have less strength in my muscles
I am having problems thinking clearly	I am very stimulated
I feel very bored	I feel physically very strained
I feel mentally very strained	I am lacking energy
I feel sleepy or drowsy	I need to rest more

Note: The following 6 items were removed from the original scale:

Sitting for a long time makes me very sleepy

The surrounding temperature is very comfortable to me

At the moment I feel very stressed

I have problems concentrating on these questions

I feel that my current activities are diversified

I feel much fitter now than after awakening

3.4.2 Pre-voyage Questionnaire

3.4.2.1 Participant Demographic Information

Information on participant demographics that were collected included open-ended questions regarding their birth year, years employed at sea, nationality, amount of time on current vessel, and the length of time spent on last vessel (Appendix B; Questions 1.1, 1.7,1.8, 1.9, & 1.10). Other nominal, closed-ended questions included participant's sex, marital status, the highest level of education attained, current ranking on the vessel, the hours the participant typically stands watch, and normal work tasks (Appendix B; Questions 1.2, 1.3 1.4, 1.5, 1.13 & 1.14). If participants did not find a suitable answer to choose from for their educational level attained or current ranking on the vessel there was an "other" option with writing space was provided.

3.4.2.2 Vessel Information

At the operational level, questions regarding a vessels current area of operation, normal work/leave system onboard, and the watch system employed on the vessel were asked (Appendix B; Questions 1.6, 1.11, & 1.12). Therefore, participants were given response options that were chosen based on the common work leave and watch systems found in this industry. If participants had an answer that differed from what was available, they were given an "other" option and asked to specify.

3.4.2.3 Variable Work Hours

Contrary to working hours being regulated in the maritime industry, working hours are often underreported. A 2003 study of the Royal Australian Navy revealed that

44% of participants worked more than 80 hours per week (Smith et al., 2003). To identify if working hours were potentially being underreported in the current research, an open-ended question regarding the number of hours of additional duties that are worked when not on watch was asked (Appendix B; Question 1.15). The participant was also asked if there were unpredictable working hours based on a 5-point Likert Scale response (1 = *often,* 5 = *almost never*; Appendix B; Question 1.19). Perceptions of safety based on these working hours were enquired through two questions that required a 3- point (yes, no, or sometimes) response from the participant: (a) Do you think the number of hours you work creates a personal health and safety risk? And (b) Do you think the number of hours you work creates a risk to the safe operations onboard the ship? (Appendix B; Questions 1.16, & 1.17). The participants was also asked if they thought the working hours have increased, decreased, or stayed the same over their career (Appendix B; Question 1.18).

3.4.2.4 Physical Work Environment

Respondents was asked to disclose if physical hazards (fumes, dust, and harmful substances) (Appendix B; Question 1.20) and ambient factors (noise, vibration, and nausea due to motion) were present in the work environment (Appendix B; Questions 1.21:1.23). A 5-point Likert Scale e (1 = *often,* 5 = *almost never)* was used for these questions. These questions were adapted from Smith et al. (2003) questionnaire.

3.4.2.5 Job Demands

The maritime industry is one of high operational demands with quick turnaround times. Perceptions of job demands placed on the participation was asked using a 5-point

Likert Scale (1 = *strongly disagree,* 5 = *strongly agree*). Time pressure due to workload, interruptions at work, heavy responsibilities, pressure to work overtime, and stress placed on the individual were the variables of interest in these questions (Appendix B; Questions 1.24:1.28). These questions were adapted from Smith et al. (2003) questionnaire.

3.4.2.7 Work at Port

Work at port may be more fatiguing for officers as they often have to be present for cargo operations, inspections, and oversee vessel maintenance. For officers who are constantly into port, this can mean continuously changing work schedules with interrupted sleeping patterns, making it difficult to establish a regular routine onboard. Two open-ended questions were asked regarding the number of port calls typically made during a tour of duty and any other additional duties that may be required in port that differ from at sea (Appendix B; Questions 2.1 & 2.7). Five more items about port work (e.g., when you are in port do you:) (a) Work the same hours at sea? (b) Work more hours than at sea? (c) Obtain time to go ashore? (d) Go ashore in off duty hours? And (e) Experience a heavier workload compared to at sea? These questions were asked to compare work in port to at sea and required a response based on a 3-point scale (yes, no sometimes; Appendix B; Questions 2.2:2.6).

3.4.2.8 Sleep Behaviours

Sleepiness may be defined as "an increased propensity to doze off or fall asleep" (Shahid et al., 2010, p. 81). Sleep deficiency has been identified to contribute to OOW fatigue (Leung et al., 2006; Lützhöft et al., 2010). The current study was interested in sleeping patterns and perceptions of sleep behaviour. Questions pertaining to sleep behaviours included an ideal length of sleep and the time a participant usually goes to bed at home. A 7-item sleep behaviour scale (Smith et al., 2003) was used to assess sleep behaviour on the vessel and included the following questions: (e.g., when are board the vessel do you: (a) Have difficulty in falling asleep? (b) Have difficulty in staying asleep? (c) Wake up during sleep? (d) Have difficulty getting up? (e) Have restless or disturbed sleep? (e) Disturb the sleep of other people? And (g) Wake up confused disorientated, irritable? These questions were measured on a 4 point scale (1 = *not at all*, 4 = *almost always*). Another 7-item scale measuring factors that could impact the quality of sleep while onboard the vessel (adapted from Smith et al., 2003; Appendix B; Questions 4.1:4.16) the included factors such as (a) noise (b) heat or cold (c) quality of bed (d) light (e) ship motion (f) other people and (g) being on call was also asked. These questions were measured using a 5 point Likert Scale (1= *not at all*, 5 = *almost always*). The participant was also asked if they shared a cabin and if it is possible to screen out daylight in their cabin as these two factors could potentially influence their sleep quality (Appendix B; Questions 4.17 & 4.18)

3.4.2.8 Health and Lifestyle Behaviours on Leave

The health and lifestyle that an individual leads while at home may also impact their quality of life at sea. Using open-ended questions, the participant was asked to report health and lifestyle behaviours while on leave including: (a) if they were a smoker and if so, how many cigarettes did they smoke each day, (b) if they consumed alcohol while on leave and if so, how much per week, and (c) the amount of physical activity performed on average for different types of exercise per week which was measured using the leisure time exercise questionnaire (Godin & Shephard, 1985; Appendix B; Questions 5.2:5.9).

3.2.4.9 Health Outcome Measures

Two health outcome variables were measured: a) mental health (General Health Questionnaire); and b) general and health well-being (MOS Short Form Health Questionnaire – SF-36).

3.2.4.9.1 General Health Questionnaire (GHQ)

The 12-item General Health Questionnaire (Goldberg, 1978, cited in Jackson, 2007) was developed as a quantifiable tool for screening individuals who may have or are at risk for developing psychiatric disorders (Jackson, 2007). There are 12, 28, 30, and 60 item versions of the GHQ available. The 12 item questionnaire was implemented in the current study to test for possible psychiatric dysfunction under three domains: (a) social dysfunction which is considered through positive phrases (6 items, e.g., been able to concentrate on whatever your doing?; Appendix B; Questions 6.1, 6.3, 6.4, 6.7, 6.8 & 6.12); (b) anxiety considered through negative phrases (4 items, e.g., lost much sleep over worry?; Appendix B; Questions 6.2, 6.5, 6.6 & 6.9); and (c) loss of confidence which is considered through negative phrases (2 items, e.g., been losing confidence in yourself? Appendix B; Questions, 6.10 & 6.11). Respondents evaluate each question based on feelings within the last three months and circle one of four choices with a total possible score ranging from 0-36 (Appendix B; Questions 6.1: 6.9).

3.4.2.9.2 MOS Short Form Health Questionnaire (SF-36)

The SF-36 is a multi-item scale that measures eight core health concepts from the longitudinal component of the MOS: (a) physical functioning; (b) role limitations due to physical health problems; (c) bodily pain; (d) social functioning; (e) general mental health; (f) vitality; (g) general health perceptions and (h) role limitations due to emotional health. This scale is largely viewed as a reliable (for vitality subscale Cronbach's $\alpha = .87$; Neuberger, 2003) and valid tool for its psychometric properties (Appendix B; Ware & Sherbourne, 1992)

3.4.3 Before Watch and After Watch Diary Questionnaires

Once participants boarded their respective vessel to go to work, they were instructed to complete a twice daily before and after watch diary questionnaire for the full duration of their seagoing trip, even when the vessel was stationed in port. Participants were requested to complete the questionnaires as close to the beginning and immediate time after their watch as possible. Each of these questionnaires took approximately five minutes to complete.

3.4.3.1 The Before Watch Diary Questionnaire

The "before watch" diary questionnaire contained 32 items to gain insight on individual behaviours prior to starting a watch. The diary first accounts for the date, current time, projected watch length, and if any alcohol was consumed the previous day (Appendix C; Questions 7.1, 7.2, 7.3, 7.4. & 7.6). Current vessel status was asked dichotomously (1= i*n port*, 2 = *at sea* (Appendix C; Questions 7.5). Besides the PMFS, all the questions in the before watch diary questionnaire were adapted from Smith et al. (2003)

3.4.3.1.1 Sleeping Patterns Before Watch

The main sleep period of the individual was examined through open-ended questions (e.g., time one went to bed, approximate time one fell asleep, waking time, sleep disruptions, and quality of sleep; Appendix C; Questions 7.7:7.11). Four questions pertaining to the sleep period as being optimal or problematic (e.g., sleep quality) were then asked on a 5-point Likert Scale (1 = *optimal*, 5 = *problematic*; e.g., "Was this sleep period sufficient?"; Appendix C; Questions 7.12:7.15).

3.4.3.1.2 Eating and Drinking Behaviours Before Watch

Eating may occur at irregular hours as a result of the individual's watch. Therefore, eating patterns were assessed through 3 items (e.g., "What did you have to eat?"; Appendix C; Questions 7.16 & 7.18) to determine if/when eating occurred and the type of food that individuals were consuming. Potentially a countermeasure to reverse fatigue symptoms, caffeine consumption was asked using a 6-point scale (1 = *none*, 6 = *5+ servings*). The same 6-point scale was also used to consider consumption of decaffeinated beverages (Appendix C; Questions 7.19 & 7.20).

3.4.3.1.3 Medication Use Before Watch

The use of 4 types of medication before the watch was asked (e.g., pain relief/anti-inflammatory, vitamins/natural substances, cardiovascular, and anti-depressants/tranquilliser) along with a "none" or "other" options (Appendix C; Question

7.21). The purpose of this question was to determine if individuals who report taking medications are potentially reporting greater fatigue. An open-ended question on the amount of tobacco products smoked since the last watch was also included as nicotine is a stimulant and may also be used to keep individuals awake (Appendix C; Question 7.22).

3.4.3.1.4 Perception of Fatigue before the Watch

Momentary perceptions of fatigue before the watch were asked with the 10-item PMFS that was previously discussed (Appendix C; Questions 7.23:7.32).

3.4.3.2 The After Watch Diary Questionnaire

The "after watch" diary questionnaire contains 38 items relevant to the watch just completed by the participant and serves as their perception of the watch. Still accounting for date and time, the actual watch length is asked to determine if an individual worked over their projected watch length (Appendix D; Questions 8.1:8.3). As a change of vessel status from either port or at sea during the course of a watch could affect the type and amount of work carried out by the participant, vessel status was asked again in the after watch questionnaire (Appendix D; Questions 8.4). Aside from where referenced, all the questions in the after watch diary questionnaire were adapted from Smith et al. (2003).

3.4.3.2.1 Eating and Drinking Behaviours after the Watch

Eating behaviours during the watch were asked to determine any food intake (Appendix D; Questions 8.5:8.6). As well, the question on caffeine or decaffeinated beverage consumption was repeated using the same 6-point scale from the before watch questionnaire to determine if consumption either increased during the course of the watch (Appendix D; Questions 8.11: 8.12).

3.4.3.2.2 Breaks During the Watch

Breaks can be restorative to a fatigued individual (Richter, Marsalek, Glatz, & Gundel, 2005). Participants were asked to record any breaks they took during the watch, along with the break type and its length. The responses to these questions were written by participants (Appendix D; Questions 8.7(a):8.9(c)).

3.4.3.2.3 Physical and Mental Workload

Workload during the watch was asked through 4 items (physical/mental effort, physical/mental demand) on a 7-point Likert Scale (1 = *not at all;* 4 = *extremely*; e.g., "Could you please indicate on the scale below how physically demanding you felt this watch was"; Appendix D; Questions 8.14:8.17).

3.4.3.2.4 Perception of Work-Related Issues

Psychosocial perceptions of work related issues were asked through a 4-point scale (1 = *not at all*, 4 = *extremely*; e.g., "I felt that I had good support from fellow co-workers if I needed it today"; Appendix D; Questions 8.20:8.24). Physical ergonomic hazards in the work environment such as fumes and air temperature were also measured using this same 4-point scale (Appendix D; Questions 8.18:8.19).

3.4.3.2.5 Physical Environment

To determine the potential influence of the physical environment on fatigue, sea state, motion, and noise were measured (Appendix D; Questions 8.26:8.28). Sea state was accounted for using the Beaufort Scale Based on Transport Canada (2003) measurements (1 = *calm,* 12 = *hurricane force*). Perceived motion (1 = *minimal*, 10 = *extreme*) and noise (1 = *very quiet*, 10 = *intense*) were both accounted for using a 10-point scale.

3.4.3.2.6 Perceived Fatigue after the Watch

Momentary perceived fatigue after the watch was measured using the adapted 10 item PMFS discussed previously (Appendix D; Questions 8.29:8.38).

3.5 Data Analyses

To determine whether there were differences across individual perceptions of fatigue, a multi-level mixed linear model was employed and results compared. All data analyses were completed using the Statistical Package for Social Sciences (SPSS) Version 17.0. Just as officers onboard various vessels are not a homogenous group, neither is their individual perception of their work environment or reported symptoms of fatigue. Officers first enter the seafaring profession at different ages with varying levels of seagoing experience and for different motivational reasons such as financial or personal.

Aside from individual differences, the cultures of private and commercial companies in the maritime industry differ as may the type of vessels found within a fleet. An individual on a vessel deployed on the Great Lakes of Ontario may experience completely different indicators of fatigue symptoms in comparison to someone who works off the Grand Banks of Newfoundland on the Atlantic Ocean. Proper analysis of fatigue in this industry should account for the varying factors that exist in this in their specific work contexts. A mixed multi-level linear model (MMLM), which considers this hierarchical structure of the data, was used to determine differences in individual perceptions of fatigue. The purpose of the following discussion is to explain and present support for the use of MMLM as a measurement tool in fatigue analysis in the maritime industry in lieu of traditional statistical methods.

MMLM, also referred to as hierarchical linear modelling, nested models, mixed linear models, random coefficients modelling or covariance components modelling (Carleglio & Makuch, 2007; Field, 2009; Sullivan, Dukes & Losina, 1999), is a statistical method that explains outcomes for individuals of a group, as well as characteristics of interest found within that group (Arnold, 1992). MMLM models have a major strength as they allow for the investigation of relationships within a particular hierarchical level and between or across these hierarchical levels (Hofmann, 1997). Two models need to be simultaneously estimated to examine both within level and between level relationships: one model of relationships within each of the lower level units and a second model depicting how these relationships within units vary between them (Beaubien, Hamman, Holt & Boehm-Davis, 2001; Hofmann, 1997; Raudenbush & Byrk, 2002). This level of modeling accounts for the hierarchical structure of the data. Issues existing in maritime fatigue research on the relationships among operational characteristics and individual fatigue outcomes can be addressed with MMLM's.

Utilized extensively in educational research where hierarchies exist naturally (e.g., students are nested within the classroom which is nested within the school which is nested within a school district, etc.), the use of MMLM as an analysis method in maritime related research would be beneficial. Hofmann (1997) contends that hierarchically ordered systems are a vital and distinguishing feature of organizations. Using Hall's (1987) definition (as found in Hofmann, 1997), he describes organizations as "…a collectively with a relatively identifiable boundary, a normative order, ranks of authority, communication systems, and membership-coordinating systems; this collectively exists on a relatively continuous basis in an environment and engages in activities that are usually related to a set of goals; the activities have outcomes for organizational members, the organization itself, and for society" (p.1).

Reinforcing putting situations into contexts, it is argued that when studying individual behaviours, attributes of the individual and features of their environment need to be addressed. In the marine industry, workers are nested into a hierarchical structure as they work towards a common goal to meet operational demands on time (Figure 3-1). Usually involved in the first level of this hierarchy is the officer and their individual characteristics (gender, age, health status, experience at sea, ranking). The experience and ranking of the officer then determines the arrangement of their watch schedule and their specific work duties on the vessel.

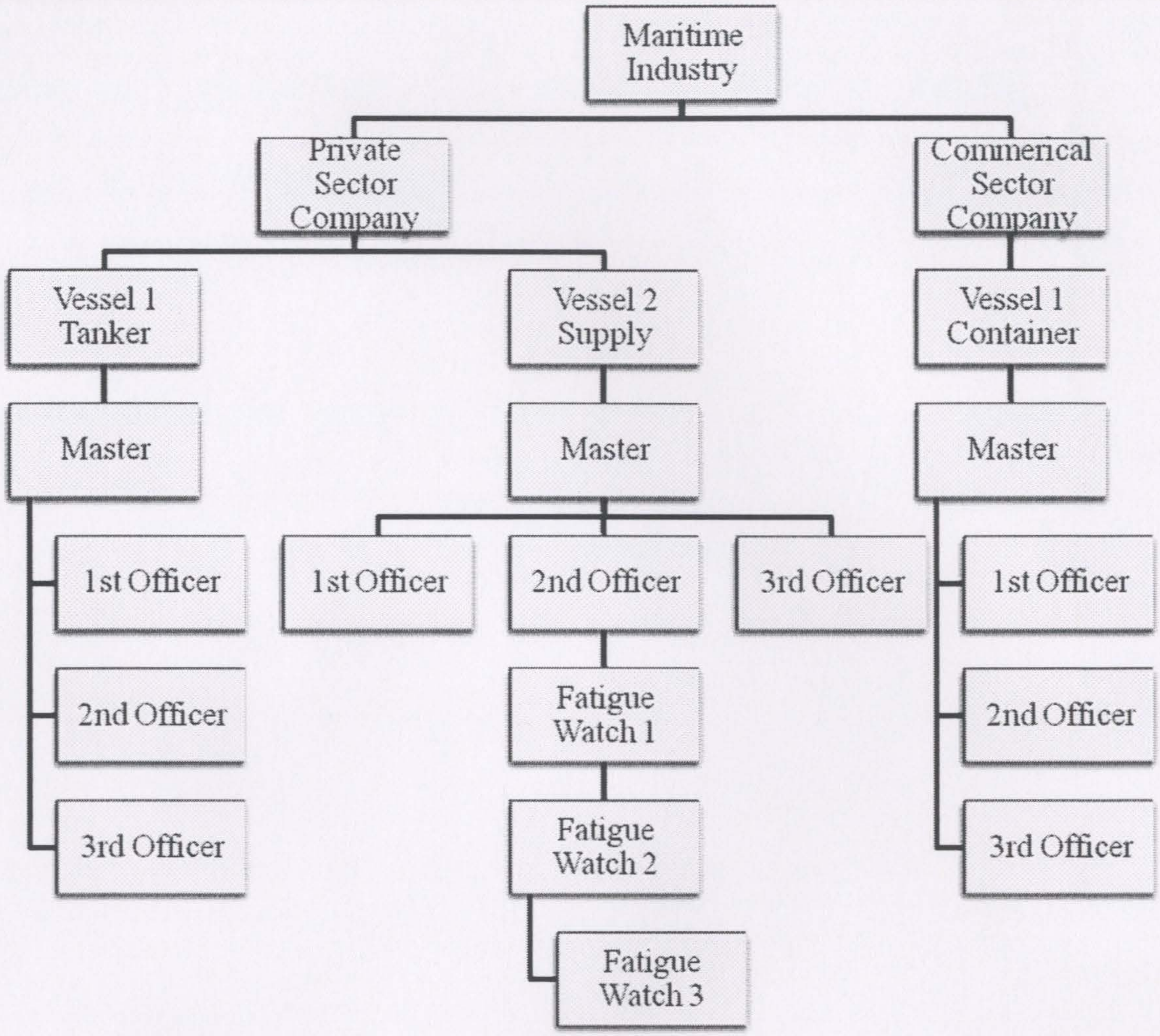

Figure 3-1: Example of a potential hierarchical structure found in the maritime industry

Officers are then nested within the operational demands on the vessel that are instructed to them by their employer. What could be considered the second level of the hierarchy, features of the vessel level may include the type (tanker, trawler, supply, container, etc.), onboard vessel characteristics (e.g., noise, sleeping arrangements), and the vessels area of operation which would then include the external sea environment which can influence the motion of the vessel. The vessel is nested within a specific company in private or commercial industry which is sanctioned by the marine industry has a whole and its rules and regulations. As industry members strive to meet demands, this hierarchical structure becomes evident. What becomes apparent based on this hierarchical structure is how it should result in analysis that differs from traditional linear analysis.

Normal linear analysis accounts for the assumptions of linearity, normality, homoscedasticity and independence. Traditionally, individuals involved in nested groups are aggregated together, which can rid of approximately 80-90% of the variation within groups, resulting in a great loss of data before analysis is ever conducted (Raudenbush & Byrk, 2002). This loss of variance could lead to misinterpretation of results as variance exists between officers found on their respective different vessels and their sector of industry on individual fatigue levels. Secondly, independence may also be violated on vessels. If officers are employed on the same vessel on consecutive watch systems, the behaviour of one watch keeping officer may influence the behaviour of another. Therefore, due to these characteristics existing at various levels they should not be placed into an equation that predicts officer fatigue outcomes at only one level. Another important benefit of using MMLM in comparison to traditional linear analysis is that the MMLM accounts for missing data, which is expected in maritime related research as different vessels have various operational schedules requiring varying tour lengths.

Regressions were first completed at the lowest level unit within the second level unit of analysis. Although data can be measured using the vessel as the second level unit of measurement, one should also think of data being nested within people, as it is applied in the current research. In these situations the case, or persons, is not at the bottom of the hierarchy (Level 1) but further up. For the example of individual fatigue in the current study, an individual's report of fatigue over the course of seagoing trip is first considered which would be a lower level unit (Figure 3-1). Then, these fatigue differences would be compared across individuals in the research that is considered second level unit (Figure 3-1). Thus, a particular factor such as fatigue may not be fixed and perfectly replicable across studies. Instead, the distinct categories present in the study or experiment represent a random sample from a larger population (e.g. the sample of officers that could be drawn from the larger seafaring population) by which the results can potentially be generalized beyond a particular study (Field, 2009). There are also some distinctions that need to be made when setting out analysis parameters for MMLM's including sample size, setting variables as fixed or random and covariance structure.

Efficient power and sample size is a complex issue with MMLM (Field, 2009; Hofmann, 1997). Generally, there is consensus that as more levels are present in the data, more parameters need to be estimated which requires a larger sample size (Field, 2009). For cross-level interactions, there should be more than 20 groups in the higher level variable and that group sizes should not be too small (Field, 2009). This criteria is met in the current study as there 21 participants are evaluated at the higher level variable. Distinction between whether the research used fixed or random effects also need to be discussed for MMLM (Field, 2009). The current research is a fixed effect as it contains all the treatment conditions of interest (e.g., a single subjective measure of fatigue), unlike a random effect that contains only a sample of possible treatments (e.g., sampling from only one type of vessel). Therefore, the results presented can only be applied to the situations presented in the current study while random effects can be generalized beyond (Field, 2009). Discussion of the input of data into the model will be discussed next.

To consider the hierarchical nature of the data, there were two levels of analysis included into separate models based on the two dependent variables of interest (before and after watch fatigue). Individuals were considered a Level 2 variable and were first entered into the model at the subject level, following with the dependent variable of interest that was entered as a first level variable. The independent variables found in the study were then added to the model. Prior to conducting analysis, the experimental effects were distinguished as fixed with consideration of random slopes and intercepts. The necessary model parameters such as using unstructured covariance to account for these parameters were set, and when an interaction term was added to the model, the covariance structure was changed from unstructured to variance components as it is the default option in this case. A maximum likelihood estimation was selected to produce more accurate estimates of the fixed regression parameters. Interactions factors such as age were added to the models for analysis after the primary analysis of a variable to determine if there was an interaction effect between that variable and the dependent variable of interest.

CHAPTER 4 RESULTS

Results of the general demographics of the participants from the pre-voyage questionnaire results will be presented first. Then, the results of the mixed multi-level linear modeling analysis across individuals will be presented. Participants completed 33.7 (SD = 15.57) before and after watch questionnaires respectively, which ranged from 16 completed watches up to 88. There were cases of missing data within the sample. For example due to attrition, only one participant completed 16 watches worth of data. Missing data in the form of completing a questionnaire from the beginning of a seagoing trip to end was present due to the distribution of some questionnaires a few days into a seagoing trip or a participant joining a vessel late or leaving early. Therefore, the total length of seagoing trip was not considered in analysis as it could not be definitively concluded of a participant's exact starting date at sea.

4.1 Participants

To acquire participant demographics and relevant work information, descriptive statistics were performed on the data set. Three participants had extensive missing data in the pre-voyage questionnaire and therefore were not included in the analysis. Seventeen males and two females were reported in the experimental sample and 76.2% were of Canadian nationality. Participants had a mean age of 39.8 years (SD = 9.84) and 68.4% were married. Most of the Officers participating in the sample were formally educated with 73.7% achieving either a college or trade certification, or a university degree with a mean experience of 18.5 years (SD = 10.52) at sea. Most of the participants were of the Second Officer ranking (33.3%), followed by Third Officer ranking (23.8%), First Officer ranking (21.1%), and Captain (5.3%) onboard their respective vessels. The most frequently reported regular duties of work are found in Figure 4-1, with watch keeping being the highest reported duty. This was an expected result as it was an inclusion criterion for participants.

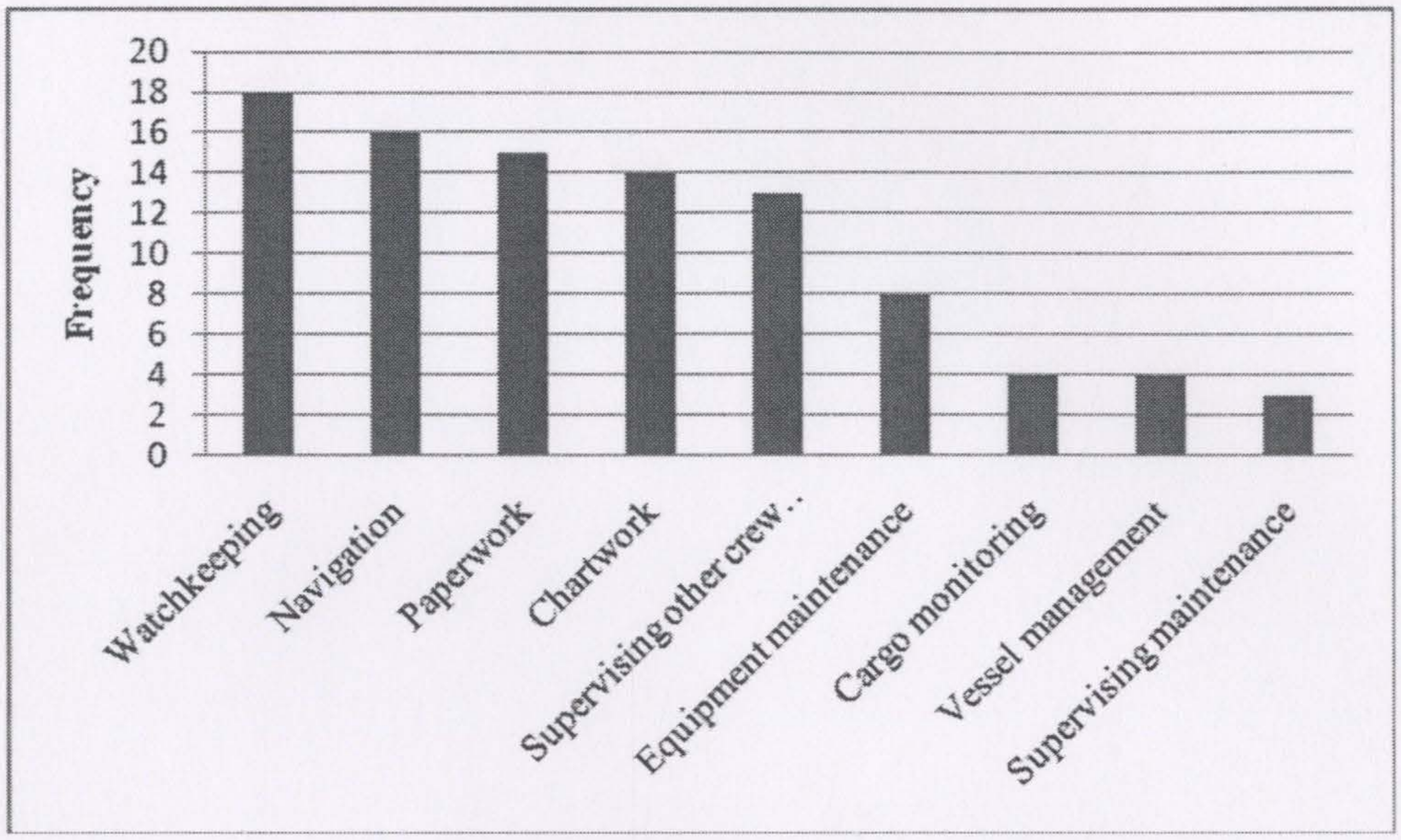

Figure 4-1: Work duties completed by participants (N = 18)

Of the vessels, 63.2% were deployed in offshore operations and the two weeks on/ two weeks off was the most commonly reported work/leave system (Figure 4-2). Most participants (61.9%) worked the 6-on,6-off watch system. With regard to these work hours, 22.2% of participants felt that their working hours have increased over their career, with 72.2% reporting them to have stayed the same. When asked if they felt that their work hours were a risk to their personal health and safety, 50.0% of participants reported sometimes, while 38.9% did not perceive any risk. Thirty-nine percent (38.9%) of participants felt that the safe operation of the ship was sometimes at stake due to the number of hours they worked, while 55.6 % disagreed with this statement. The average call to port per tour of duty was 1.7 visits (*SD* = 1.74), with 66.7% agreeing that they work the same hours at sea as in port, but 50% reported sometimes receiving a heavier workload during this time.

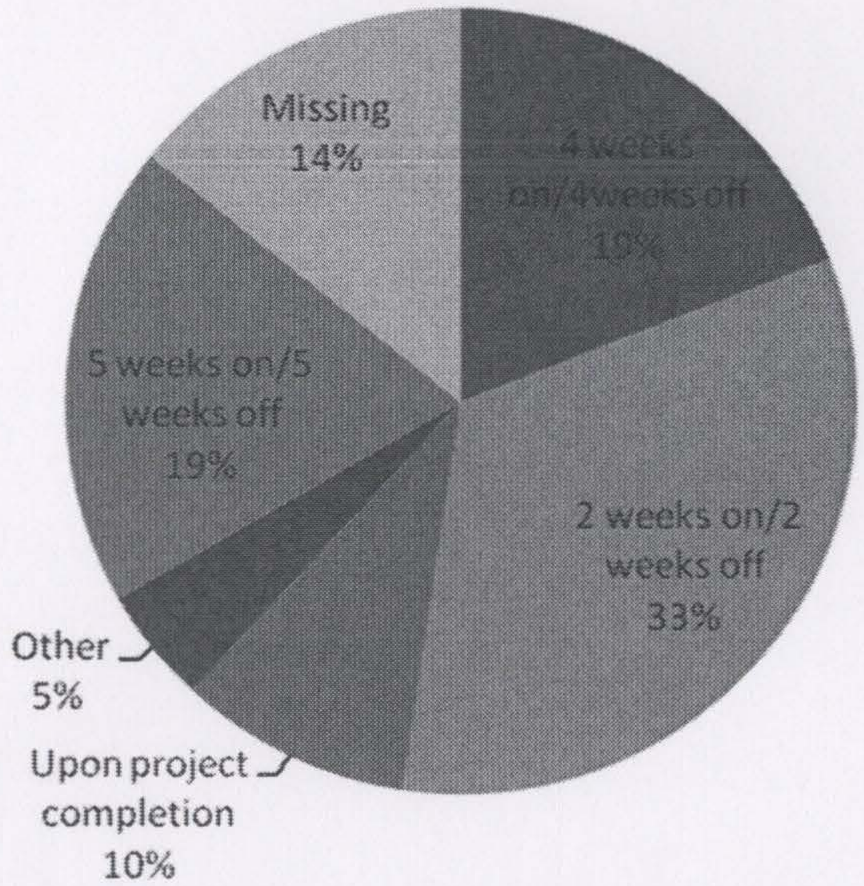

Figure 4-2: Work/leave system employed on participant vessels (N = 18)

When asked about their perception of experiencing symptoms of fatigue while at sea, participants reported to experience moderate to minimal symptoms of each (Table 4.1). Seventeen percent (16.5%) of participants reported that they had a fatigue related near miss or that they had been responsible for an accident on five or less occasions. With regards to napping while on watch, 5.6% participants mentioned they found themselves napping on watch and 16.7% of participants reported they sometimes did.

Table 4.1

*Symptoms of fatigue reported at sea by participants**

Symptom	M	SD
Confusion	4.18	.728
Tired	2.59	.618
Poor Sleep Quality	2.61	.698
Depression	4.44	.784
Tension	3.69	.825
Loss of Concentration	3.78	.808

*(N = 18)

Participant perception of their work environment is presented in Table 4.2. Usually less than half of the participants reported often or sometimes experiencing negative characteristics in their work environment. Therefore, most participants did not appear to experience negative characteristics in their work environment.

Table 4.2

*Participant Perception of Characteristics of their Work Environment (Valid Percents)**

Question	Often	Sometimes	Seldom	Never	Almost Never
Breathing of fumes, dusts, or other potentially harmful substances	11.1	33.3	22.2	5.6	27.8
Background noise that disturbs concentration	11.1	22.2	44.4	16.7	5.6
Vibration affecting performance		22.2	27.8	44.4	5.6
Feelings of nausea from motion effects		11.1	22.2	55.6	11.1

*(N = 18)

Over the course of a week while on leave, 12.1% of participants reported to often engage physical activity long enough to work up a sweat. During this time, participants reported to participate in forms of mild (*M* = 5.21, *SD* = 3.551), moderate (*M* = 4.31, *SD* = 1.877), and/or strenuous exercise (*M* = 1.77, *SD* = 2.227) over the course of a seven day period. Average alcohol consumption reported while on leave was on 10.3 units per week *(SD* = 9.55) with an average of 5.4 cigarettes smoked per day *(SD* = 9.58). Joint and muscular pain was the most commonly reported health complaint, followed by viral infections/colds/sore throats, skin complaints and headaches (Figure 4-3). Digestive disorders did not appear to be a health concern among participants.

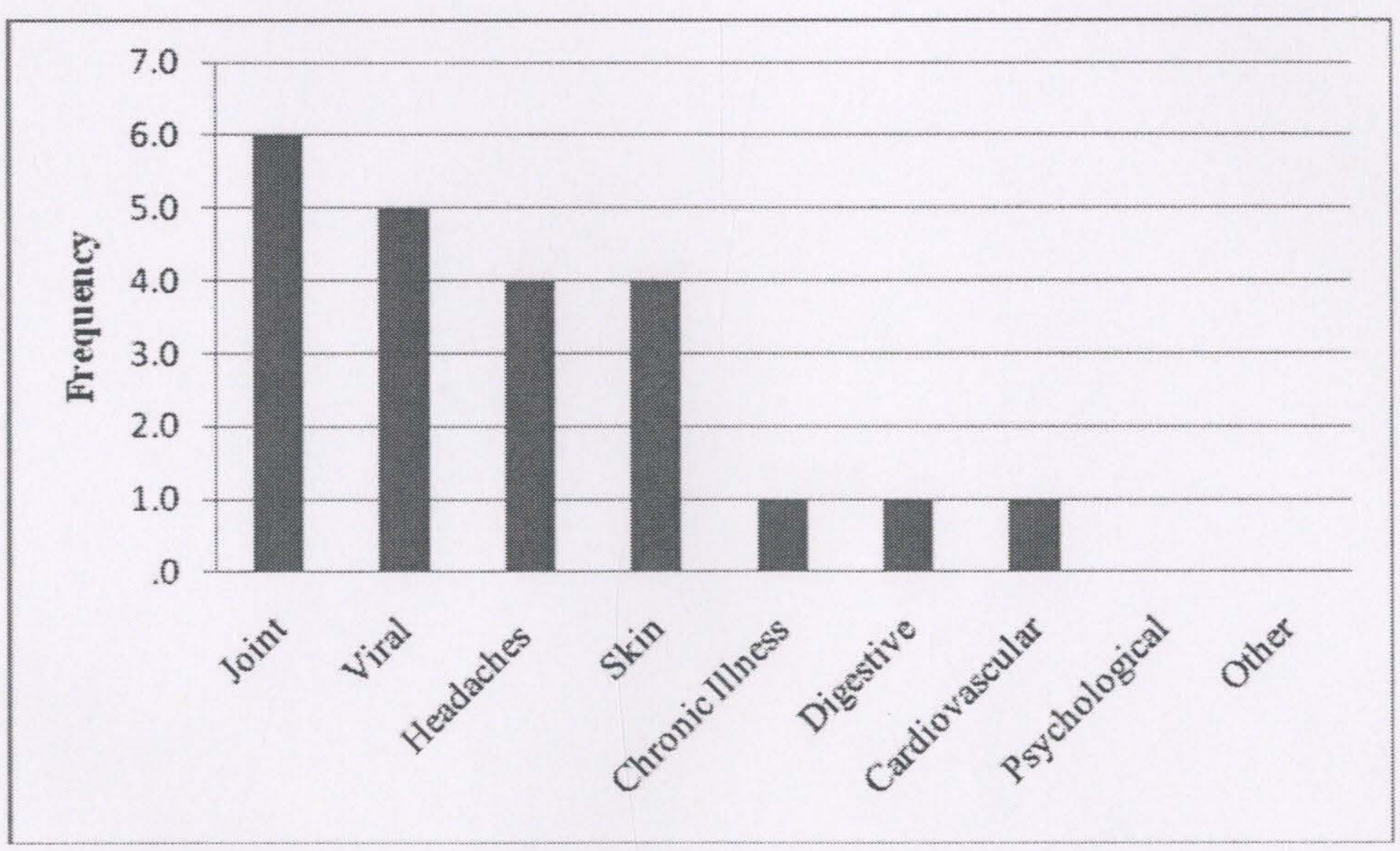

Figure 4-3: Common health complaints by participants (N= 18)

Participants reported their ideal sleep length while on leave to be 7.11 hours (*SD* = 1.08). None of the participants reported to share a cabin and all reported being able to screen out daylight in their cabin while onboard their respective vessel (N = 18). Participants were also asked about their sleep information on the vessel and how often sleep disturbances or trouble difficulties occurred (Table 4.3). It would appear that participants most often reported waking up during their sleep, having a restless or disturbed sleep, having difficulty in staying asleep, or falling asleep. Participants were also asked if their sleep quality was impacted by factors such as noise, light, or the quality of their bed. Noise ($M = 3.33$, $SD = 1.237$), ship motion ($M = 3.22$, $SD = 1.215$), and hot or cold ($M = 2.61$, $SD = 1.243$) were reported to impact sleep quality the most.

Table 4.3

*Participant perception of sleep onboard the vessel (Valid Percents)**

Question	Not at all			Almost Always
Have difficulty in falling asleep	5.6	44.4	38.9	11.1
Have difficulty in staying asleep	5.6	38.9	38.9	16.7
Wake up during sleep		22.2	38.9	38.9
Have difficulty getting up	33.3	38.9	16.7	11.1
Have restless or disturbed sleep	11.1	33.3	44.4	11.1
Disturb the sleep of other people	94.4	5.6		
Wake up confused, disorientated, irritable	50.0	33.3	16.7	

*(N =18)

4.2 Before and After Watch Questionnaire: Multi-Level Linear Modelling Analysis

Due to violations of normality as a result of the ecological fallacy nature of the data, a mixed multi-level linear model analysis was employed on the data to examine if there were differences in individual perceptions of fatigue and associated indicators.

Separate models were used for each of the dependent variables of interest (before watch fatigue and after watch fatigue). Variables of interest and interaction terms where then added to each model separately based on the research questions found in Chapter 1.

4.2.1 Before and After Watch Perceptions of Fatigue

Before watch fatigue perceptions significantly predicted after watch fatigue perceptions across participants ($F_{(1,\ 677.20)}$ = 241.16, p < .001). This analysis shows that when individuals reported their before watch fatigue to be higher, there was also an increase in their after watch fatigue perceptions (b= .480, $t_{(677.20)}$ = 15.29, p < .001). The intercepts' also varied among participants (var $_{(u0j)}$ = 12.38, $\chi^2_{(7)}$ = 3988.25, p < .01), demonstrating individuals had different perceptions of fatigue at their baseline reported watch. Adding "watch" as a covariate factor to determine if there was a relationship with the reported watch on before and after watch perceptions of fatigue did not significantly effect the model ($F_{(1,\ 13.12)}$ = 1.58, p = .231), meaning that a specific watch did not effect after watch fatigue perceptions. When age and experience were each separately added to the model to be considered there was an interaction in predicting after watch fatigue, there was no effect found with either.

4.2.2 Caffeine Consumption

The interaction between caffeine consumed prior to the watch and the specific watch reported on before watch fatigue was conducted. There was no specific effect on the reported watch and the before watch perceptions of fatigue ($F_{(1,\ 20.39)}$ = .333, p = .57). The amount of caffeine consumed prior to the watch and its effect on before watch perceptions of fatigue was found to be approaching significance ($F_{(1, 685.92)} = 3.37$, $p = .067$), and the interaction between a specific watch and the amount of caffeine consumed prior to the watch was found to effect before watch perceptions of fatigue across individuals ($F_{(1, 669.60)} = 4.91$, $p < .05$). This analysis shows that for a specific watch reported, caffeine consumed before the watch significantly predicted before watch fatigue ($b = .058$, $t_{(669.60)} = 2.22$, $p < .05$): individuals during these watches who had increased their caffeine consumption had slightly higher perceptions of before watch fatigue.

Therefore, caffeine may potentially be used as a coping mechanism to alleviate symptoms of fatigue. To further probe this question and see if caffeine consumption was age related, age was added as an interaction factor into the model. When age was added to the model, there was found to be no interaction between age, the specific watch reported and before watch caffeine consumption on before watch fatigue scores across individuals, indicating that older or younger individuals were not specifically using caffeine more often as a coping mechanism before the watch.

To further determine if caffeine may have been used as a coping mechanism to alleviate symptoms of fatigue, analysis was carried out using the interaction between before watch fatigue and the amount of caffeine consumed prior to the watch with after watch fatigue. It was found that the interaction of caffeine consumed prior to the watch and before watch fatigue both significantly predicted watch fatigue perceptions ($F_{(1, 664.40)} = 12.73$, $p < .001$). This is a reasonable finding as an individual may feel symptoms of fatigue prior to going to work, intake caffeine to deal with these symptoms, which still carry over across the watch. Age was then added into the model to determine if there was an interaction between age, caffeine consumption prior to the watch and before watch fatigue on after watch fatigue perceptions. The results of this interaction were found to significantly predict after watch fatigue ($F_{(1,\ 599.23)} = 4.16$, $p < .05$). These findings show that with a very slight increase in age, there is an interaction with increased caffeine consumption and before watch fatigue perceptions on after watch fatigue ($b = .0040$, $t_{(599.23)} = 4.16$, $p < .05$). This increase however, is not very large.

To determine if caffeine was a coping mechanism to alleviate perceptions of fatigue during the watch, caffeine consumed during the watch was placed into the model as a separate interaction factor. The results indicate that when caffeine consumed during the watch was added as an interaction factor into the model, before watch fatigue perceptions still had an effect on after watch fatigue perceptions ($F_{(1,\ 682.47)} = 225.64$, $p < .001$). The amount caffeine consumed during the watch was found to effect after watch perceptions of fatigue across individuals ($F_{(1,\ 566.88)} = 9.04$, $p < .010$). This analysis shows that for those individuals who consumed higher amounts of caffeine during the watch, it significantly predicted after watch perceptions of fatigue ($b = -1.18$, $t_{(566.88)} = -3.01$, $p < .01$): fatigue was reported to be lower in these individuals compared to individuals who did not consume caffeine.

There was also an effect between the interaction of the specific watch reported and caffeine consumed during the watch on after watch fatigue perceptions ($F_{(1,\ 461.89)} = 7.31$, $p <.010$). These analyses also demonstrate that when a specific watch is considered, caffeine consumed during the watch significantly predicted after watch fatigue across individuals ($b = .036$, $t_{(461.89)} = 2.70$, $p < .01$) individuals during these watches who had increased their caffeine consumption had slightly higher perceptions of after watch fatigue.

To determine if individuals might be using caffeine to cope as a result of poor sleep quality, sleep quality was added to the model as an interaction factor. When sleep quality was added, it was found that there was a strong, significant effect on perceived sleep quality and before watch perceptions of fatigue across individuals ($F_{(1,\ 664.15)}$ = 305.14, $p < .001$). These individuals who reported more problematic sleep quality had an increase in before watch fatigue scores ($b = .988$, $t_{(664.15)} = 17.47$, $p < .001$). However, there was no significant interaction found between a specific watch, sleep quality, and before watch caffeine consumption on before watch perceptions of fatigue ($F_{(1,464.48)}$ = .035, $p = .853$) nor between the interaction of caffeine consumption prior to the watch and sleep quality on before watch perceptions of fatigue ($F_{(1,640.83)} = .197$, $p = .657$). An interesting observation was that when this interaction factor was included, the effect of the interaction between caffeine, a specific watch and before watch fatigue became insignificant ($F_{(1,341.67)} = 1.67$, $p = .197$), indicating that sleep quality is more of a contributing factor to before watch fatigue and caffeine may be just used a mechanism to alleviate these symptoms.

4.2.3 Sleep Quality

To determine the effect of sleep quality on before watch fatigue, the four variables found defining sleep quality in the study (ease of arising, ease of falling asleep, sufficient sleep, and how deep the sleep was) were compared with before watch perceptions of fatigue. For this model, the main effect of sleep quality was removed to account for each of these specific variables. The watch was still found to not be significant with before watch perceptions of fatigue and neither was the ease of sleep ($F_{(1, 678.18)} = .334, p = .564$). Ease of arising ($F_{(1, 686.18)} = 70.84, p < .001; b = 1.65, t_{(686.18)} = 8.42$, $p < .001$); sufficient sleep ($F_{(1, 676.61)} = 82.86, p < .001; b = 1.70, t_{(676.61)} = 9.10$, $p < .001$), and deep sleep ($F_{(1, 678.04)} = 18.33, p < .001; b = .83, t_{(678.04)} = 4.28$, $p < .001$) were all found to significantly effect perceptions of before watch fatigue. These positive results show that across individuals, as each of these factors of sleep quality were found to be more problematic, there was an increase perception of before watch fatigue.

To determine if there was an interaction with age on these factors and before watch perceptions of fatigue, age was added as an interaction factor into the model. It was found that there was an interaction between age and the ease of arising on before watch perceptions of fatigue ($F_{(1,612.62)} = 22.06, p < .001$). The positive result shows that in these individuals, the ease of arising was slightly more difficult in older individuals and they had higher perceptions of before watch fatigue at this time ($b = .107, t_{(612.62)} = 4.70, p < .001$).

The interaction between each of the four sleep quality factors and before watch fatigue were taken to further determine if there was an effect on after watch perceptions of fatigue across individuals. Of these four factors, it was found that the interaction between how deep the sleep was and before watch perceptions of fatigue had a significant effect across individuals on their after watch fatigue perceptions ($F_{(1, 680.59)} = 10.75, p = .001$). The positive result shows that with before watch perceptions of fatigue, how deep the sleep was perceived to be significantly predicted after watch fatigue perceptions (b = .068, $t_{(680.59)} = 3.28$, $p < .001$).

4.2.4 Environmental Conditions

Environmental factors such as noise, ship motion, and sea state were evaluated to determine if they contribute to an individual's perception of fatigue reported after the watch. Noise ($F_{(1, 694.44)} = 42.99$, $p < .001$) and motion ($F_{(1,687.22)} = 4.98$, $p < .05$) were found to effect perceptions of after watch fatigue across individuals. These analyses show that the noise ($b = 1.14$, $t_{(694.44)} = 6.55$, $p < .001$) and motion ($b = .72$, $t_{(687.22)} = 2.23$, $p < .05$), positively and significantly predict after watch fatigue, indicating that in these individuals, they had higher perceptions of after watch fatigue when they reported the noise and motion in their environment to be higher.

4.2.5 Physical and Mental Work Factors

Of the four variables considering the demands and effort (physical demand, physical effort, mental demand, and mental effort) of the watch, only physical demand ($F_{(1, 674.60)} = 15.20$, $p < .01$) and mental demand ($F_{(1, 684.86)} = 4.09$, $p < .05$) were found to effect after watch fatigue perceptions across individuals. These analyses indicate that as perceptions of physical demand ($b = .97$, $t_{(674.60)} = 3.90$, $p < .01$) and mental demand increased ($b = .68$, $t_{(684.86)} = 2.02$, $p < .05$), so did after watch perceptions of fatigue. Neither age nor experience were determined to be significant interaction factors in this model.

The general aspects of performing navigational watches is generally less physically demanding, so the individual may have been compensating for increased biomechanical response to vessel motions. While there was no significant finding between the interaction of physical demand and motion on after watch fatigue ($F_{(1, 675.93)}$= 2.08, p = .150), there was an effect on the interaction between a specific shift, the vessel motion and physical demand on after watch symptoms of fatigue across individuals ($F_{(1, 689.29)}$ = 6.96, p < .01). These results show that a slight increase in physical demand with increase motion for specific shifts increases perceptions of after watch fatigue in individuals (b = .005, $t_{(689.29)}$ = 2.64 , p < .01). When noise was added into the model as an interaction factor, there was no significant effect with mental demands and after watch fatigue ($F_{(1, 683.37)}$ = .315, p = .575).

4.2.6 Psychosocial Factors

Psychosocial factors and their relationship on after watch fatigue perceptions across individuals were considered last. Of these factors, harmful substances ($F_{(1, 654.39)}$ = 7.78, p < .01; b = 1.11, $t_{(654.39)}$ = .279 , p < .01), too much work ($F_{(1, 665.30)}$ = 4.69, p < .05; b = .722, $t_{(665.30)}$ = 4.69 , p < .05), and stressful work ($F_{(1, 672.79)}$ = 23.3, p < .001; b = 1.16, $t_{(672.79)}$ = 4.83, p < .001) were found to significantly effect after watch perceptions of fatigue. There was found to be no interaction when age was included into this model.

CHAPTER 5 DISCUSSION

This study investigated whether different factors contributed to subjective perceptions of fatigue in officers of the watch. Research in the area of fatigue among OOW tends to solely focus on only one domain of fatigue indicators (e.g., watch standing schedule; sleep). However, the present investigation examined different domains of fatigue contributors (individual, occupational, and environmental), thus providing a more holistic perspective of the subjective perception of fatigue of OOW. The design of this study is also unique to this field in that fatigue is assessed subjectively in real-time rather than retrospectively.

Self-report measures have been criticized for inherent errors and biases stemming from the characteristics of autobiographical memory (Shiffman & Stone, 1998). In retrospective survey methods, individuals rely on heuristic strategies for recall of perceived feelings or frequency of events and behaviours because they are unable to accurately retrieve and summarize all records in memory. Momentary questionnaires have been established to address these concerns through the collection of moment by moment data in real-world settings. The trademark of these questionnaires is that a collection of repeated momentary assessments is obtained from participants in their natural environment (Shiffman & Stone, 1998). Stronger ecological validity is then demonstrated as data are collected during real-life situations. This study investigated if there was a difference in the findings of fatigue indicators across individuals using mixed multilevel linear models.

Considering the interaction between multiple factors is important, as Wadsworth et al. (2008) highlights: "Fatigue should be addressed by considering how multiple factors combine to cause fatigue" (p.203). Wadsworth et al. (2008) also conclude their study by suggesting that, "approaches to managing seafarers' fatigue therefore needs to be flexible enough to represent individual circumstances" (p.203). Based on just conducting sample analysis, these proposed suggestions by Wadsworth et al. (2008) would be limited and findings directing fatigue management could be misdirected. Contrary, both of these issues were addressed through the MMLM analysis used in the research.

Due to the nature of the research, it was important to assess the potential significance of the indicators that may contribute to fatigue as individuals were found on different vessels, stationed in different locations and sometimes from different organizations. Mixed multilevel linear modeling enabled these differences to be accounted for as these factors were analyzed at the individual level. The findings of the study demonstrated the strength that some of these factors have on perceptions of fatigue.

The use of MMLM has great potential for fatigue research in the maritime industry. To date, there has been a few studies reporting a similar method of analysis (e.g., Grech, Neal, Yeo, Smith, & Humphreys, 2009; Härmä et al., 2008). This model could also be extended further to make comparisons among vessels and the different occupations found on each one (something that was unavailable in the current study due to ethical limitations). These findings can guide and strengthen fatigue mitigation programs used by stakeholders and regulators in the maritime industry, strengthening support for this analysis tool. This chapter will present a discussion of the findings of this investigation, the caveats and limitations of the study, and recommendations for fatigue mitigation programs and future research are suggested.

5.1 Before and After Watch Fatigue Perceptions

The current study found before watch fatigue perceptions to strongly effect after watch fatigue perceptions (see 4.2.1 Before and After Watch Perceptions of Fatigue). From these results, it can be concluded that the relationship between before watch and after watch fatigue perceptions vary significantly across individuals, highlighting the individual variation in fatigue. These findings are not surprising as it would be expected for individuals to vary in their perception of fatigue symptoms. Therefore, these results serve as a baseline for the inclusion of the other factors that may affect these individual perceptions of fatigue that may not be distinguished at the group level.

5.2 Caffeine Consumption

The consumption of caffeine was considered three different ways- consumption prior to the watch; consumption during the watch; and the difference between caffeine consumed during the watch and prior too (see 4.2.2 Caffeine Consumption). There were significant findings of caffeine consumed before or during the watch and increased perceptions of fatigue before and after the watch respectively across individuals. This consumption was also found to be significant with specific watches reported.

There was an important finding in the direction of the significance for caffeine consumption. A negative relationship was found between caffeine consumed during the watch and after watch fatigue perceptions, indicating that individuals who increased their caffeine consumption reported lower levels of fatigue. However, when a specific watch was considered in the model, there was a positive relationship, indicating that individuals who increased their caffeine consumption on specific watches reported higher levels of after watch fatigue. These results emphasize the use of caffeine as a coping mechanism to alleviate fatigue. For individuals who increase their caffeine consumption during the watch, it may mask the symptoms of fatigue temporarily. However, it may also be interpreted that on specific watches when individuals are struggling with the effects of fatigue, they increase their caffeine consumption to try and alleviate these symptoms.

Gawron et al. (2001) state that "individuals choose and modify coping strategies and motivational factors based on their fatigue levels and the changing demands of the task" (p. 585). Therefore, individuals use self-monitoring to decide which coping strategy will be more beneficial. For those who decide to use caffeine as a countermeasure, it has been found that prophylactic of use caffeine before the onset of symptoms such as sleepiness is more effective than trying to use caffeine to reverse the symptoms (Åkerstedt & Wright, 2009). In the current study, individuals who still reported an increase in fatigue during a specific watch even after caffeine consumption may have been unsuccessfully trying use caffeine as a coping mechanism to alleviate fatigue symptoms.

Age was also found to be an interacting factor with caffeine consumed prior to the watch and after watch perception of fatigue. What may be concluded is that when some older individuals are feeling stronger symptoms of fatigue prior to a watch, they utilize caffeine as a coping mechanism. These findings are important for fatigue mitigation as substantial intakes of caffeine can have negative health benefits. Therefore, other approaches to reduce fatigue should be promoted (e.g., good nutrition, good physical conditioning, and sleep) and discussed with individuals for proper remediation.

5.3 Sleep Quality

Sleep and sleep quality issues were found to be a significant predictor of fatigue across individuals (see 4.2.3 Sleep Quality). Participants reported to sometimes nap while on watch, which can pose serious risk to the crew and vessel safety. Härmä et al. (2008) reported similar findings in a cohort of Finnish maritime officers who reported falling asleep at least once while on duty during their career. Participants in the study also noted the difficulty surrounding sleep issues with statements such as "did not sleep; woke up at 4 and couldn't sleep" (Participant 9). These references to poor sleep quality were voluntary in nature as the study did not require participants to provide such statements. These statements recognize that participants may not be achieving adequate restorative rest between watches. This is supported by Louie and Doolen (2007) who found that seafarers rated a lack of sleep and inconsistent sleep times to be the leading contributors to fatigue.

The perception of the ease of sleep and sufficiency of sleep were also very valuable in determining before watch perceptions of fatigue. Ease and quantity of sleep increased before watch fatigue perceptions almost twofold. These findings emphasize the importance of having suitable sleeping quarters in place for seafarers that can optimize sleep (e.g., darkened and quiet quarters) and also ensuring that there is enough time between watches for sufficient, restorative sleep. Company policies should also include guidance measures for seafarers to maintain proper rest onboard. A culture among crewmembers stressing the importance of gaining proper sleep can be facilitated through such organizational support. Participant statements and current study findings support the growing amount of literature on the poor sleeping patterns of seafarers (Härmä et al., 2008; Lützhöft et al., 2010; Sanquist et al., 1997).

The significance of age and sleep was also demonstrated as older participants were found to have higher fatigue perceptions before the watch due to difficulties in their ease of arising. Also, if these older participants reported that deep sleep was problematic, they reported higher perceptions of fatigue after the watch. From these findings, it could be assumed that age may be a contributing factor to fatigue due to an increased need to recover from the demands of work. However, in their research of older seafarers, Bridger et al. (2010) reference that unlike other occupations; age has not been found to conclusively associate with this need for recovery in seafarers. With mixed results found within this study compared to other relevant literature, coupled with a continuously aging workforce, further research is needed to clarify if increasing seafarer age associates with the ability to successfully recover from the demands of work.

5.4 Environmental Factors

Noise had a significant effect on after watch fatigue perceptions (see 4.2.4 Environmental Conditions). As noise perception was reported to be higher in the work environment, the direction of the relationship with after watch fatigue increased by over one whole unit. The implications of noise can lead to increases in stress, decrements in performance, sleep disturbances and communication interferences (Grech et al., 2008).

While the specific type of noise was not specified in the current study, it is evident that it was sufficient enough to negatively effect perceptions of fatigue.

The findings for the current study of the effects of noise and motion do not agree with the findings of Smith et al. (2003). In their study, the subjective measures of noise and motion were not found to predict any of the fatigue outcomes. Smith et al. (2003) attribute this lack of finding to the general consistent noise levels found onboard their study vessels, with few rapid changes in noise or loud, unexpected noises. Therefore, further research should ask for the specification for the type of noise so that it can be distinguished the specific type of noise that may have led to these increased subjective perceptions of fatigue.

The findings of subjective measures of noise and motion to predict after watch fatigue may also relate to the season. Data were collected from some participants during the winter months. During this season, sea states and environmental conditions tend to be severe and individuals also have to be on watch for icebergs and foggy conditions. During these times individuals may also report higher levels of fatigue as they cope with the increased physical demands resulting from motion induced fatigue. These demands maybe supported by an interaction between increased physical demands and motion during specific reported watches in the current study. Therefore, individuals may be expending more energy to control against motion induced interruptions, resulting in increased motion-induced fatigue and concomitant overall physical fatigue (Colwell, 2005; Marais et al., 2010).

5.5 Physical and Mental Work Factors/Other Psychosocial Factors

Work demands have been found to be associated with seafarer fatigue (Louie & Doolen, 2007; Wadsworth et al., 2008). In the current study, increased physical and mental work demands were found to associate with increased after watch perceptions of fatigue (see 4.2.5 Physical and Mental Work Factors). Increased physical demands were also found to associate with increased vessel motion during specific watches. These mental demands may have increased as a result of an increased workload or the need to maintain vigilance during critical sailing situations. While these factors reinforce that an OOW work duties can be physically demanding, future research should ask what aspects may cause higher perceptions of physical and mental demands to identify specific work tasks that may lead to these increases.

Stress has also been referenced to be a significant issue in seafaring (Comperatore, Rivera & Kingsley, 2005) and an indicator of fatigue in previous research studies (Louie & Doolen, 2007; Wadsworth et al., 2008). The current research also found stress to be a significant concern (see 4.2.6 Psychosocial Factors). Aside from working in a stressful environment, other sources of stress can arise from the organizational culture present onboard a vessel. It was noted in the current research that "...the length of my workday may depend on tides or on the mood of the chief officer. (hard to predict ☺)" (Participant 16). This autocratic leadership style (Grech et al., 2008) with a lack of communication and information sharing to the crew could lead to the disengagement of crewmembers to their subordinates. Being uninformed of when the watch could end could have led to higher perceptions of stress among some individuals.

Another factor, "too much work", was also found to significantly increase perceptions of after watch fatigue. This supports previous reports in the literature that navigational officers can be overburdened with extra work and the demands placed on them. These demands are most often in the form of paperwork, which can lead to working outside regular work hours to meet these demands. In the study, participants reported a lot of their work tasks to include paperwork, chart work, and supervising other crew members. Smith et al. (2003) also observed high work demands in their study and when asked what three measures could best reduce fatigue; the top three participant answers were extra manning, more leave, and less paperwork.

5.6 Summary

The results from the MMLM analysis further highlight the numerous factors that are correlated to fatigue. These data suggest that sleep quality is an important indicator of fatigue, further supporting findings in the literature. These results also suggest that in addition to problematic sleep quality, environmental factors such as noise and motion can greatly effect perceptions of fatigue. For vessel motion, this may also lead to increased physical demand as individuals compensate to maintain balance under greater vessel motion. In addition, psychosocial factors such as work stress and the amount of work are also important contributors to fatigue, reinforcing that officers may still be overburdened with the work demands placed on them.

5.7 Strengths, Caveats and Limitations

Caveats and limitations are found within the study. The generalizability of the results to a larger seafarer population is limited. The sample consisted of watch standing officers mainly of Canadian nationality, limiting the ability to generalize the results of this study to other occupations onboard the vessel such as marine engineers and individuals of different nationalities (see 3.4.2.1 Participant Demographic Information). This study also lacked a control group, making it difficult to determine the extent to which the findings of this study may be found in the general onshore population.

A main limitation of this study was the sample size. The study aimed to establish a profile of the risk factors that may contribute to subjective fatigue. Due to the limited number of participants, statistical interpretations were achieved but the development of a comprehensive fatigue model was not possible. A lack of participants were not due to poor recruitment efforts, but with a smaller based maritime sector (825 deck officers reported in the 2006 Census, Newfoundland and Labrador Statistics Agency, n.d.) compared to other nations in the world, there was a smaller OOW population to draw from. Other notable studies in the area were found to have participant numbers of: 185 (Härmä et al., 2008); 93 (Leung et al., 2006); 43 (Louie & Doolen); 30 (Lützhöft et al., 2010) and 1855 (Wadsworth et al., 2008) respectively. Recruitment techniques for the current study included contacting all companies deploying in the region through e-mail or telephone, networking at various marine expositions, presenting to industry affiliated groups and one-on-one meetings with participants.

Another limitation due to this sample size was an inability to make comparisons among different watch systems employed in the marine industry. The literature has inferred that there may be differences in perceptions of fatigue based on the watch system type (Härmä et al., 2008; Lützhöft et al., 2010; Rutenfranz et al, 1988; Sanquist et al., 1997). However, most of the participants were on the 6-on, 6-off watch system, making this comparison unobtainable.

The study was completed with no reimbursement for individual participation. Therefore, participants were asked to complete the study questionnaires multiple times during the entire length of a seagoing trip without any compensation for their involvement and then were responsible for sending them back to the researcher. This could have led to participant attrition as individuals did not feel compelled or motivated to complete and return the research package. Those who did complete and return the research were likely individuals who believed in the importance of gathering quantitative fatigue data.

A lack of funding was also an issue in that it did not allow the research to extend vastly across Canada or have a research observer onboard any of the participating vessels. While having a researcher onboard could lead to an observer effect, this individual could serve as a reminder for individuals to complete questionnaires and also make observations of individual work patterns onboard that could be missed in the questionnaire content. However, it may also not be practical or feasible to have researchers onboard a vessel for extended periods of time to collect data from only several individuals. Therefore, mostly

Canadian vessels deployed in the Atlantic regions were recruited for participation because of their accessibility to the researcher.

Ethical considerations also limited the ability to make comparisons of interest within the research. For ethical reasons, the type of vessel that participants were employed on was asked to be omitted from the questionnaire. This omission meant that comparisons among different vessel types could not be made. This observation is important to maritime fatigue research as the different operational demands on vessels determine their port turnaround time and work schedule.

This study aimed to determine if perceptions of OOW fatigue change over the course of a seagoing trip. The researcher did her best to ensure that participants received their research package at the beginning of a sea going trip, but this was not always possible due to vessel scheduling and timing. Therefore, questionnaires were not always completed for the full duration of trip, making this generalization unavailable. Comparisons were made for the length of time that questionnaires were completed, but a definitive conclusion about total fatigue perceptions from the beginning of a seagoing trip to the end cannot be established.

Familiarity of participant response to the data collection protocol (e.g., validity of participant response to the questionnaire) may have occurred over the course of the tour. As days into their tour increased, participants may have become complacent in their responses. As there were no objective measures of fatigue employed in the current research to correlate with the subjective measures, it can only be assumed that participants followed the research protocol and completed the questionnaires accurately.

Although not a negative issue from a health standpoint, new employee health and wellness initiatives that are being utilized on vessels may have been another limiting factor for this study. These initiatives include providing nutritional information and advice to seafarers while onboard the vessels, physical activity incentives, and information on how to achieve good lifestyle habits both on the vessel and at home. Some vessels openly admitted to being involved with these programs and others not. Therefore it could not be determined which participants may have had these initiatives in place which could have led to influential difference in fatigue perceptions (better or worse) in comparison to someone who did not.

The mixed multilevel model analysis allowed for the examination of perceptions of fatigue and its indicators across individuals. This study is currently among one of the few to use this model in human factors research in the maritime industry. As an analysis method, this model is still relatively new and predominately used in educational research. Therefore, there are methodological issues surrounding the reporting and transparency of data (Dedrick et al., 2009). The current research made every effort to soundly report methodological practices within this data set for transparency.

5.8 Future Research

Despite limitations present in the current study, it is important to consider that this study was very exploratory in nature. The current study utilized a testing measurement that had only been used once before in another continent (Smith et al., 2003). The questionnaire utilized in the current research provides a comprehensive assessment of the various factors that found within an OOW work environment. Future research should explore further use of the measurement tools found in the current research as it could provide greater insight into critical fatigue factors in the maritime industry. The PMF scale presented in this study would be of great benefit to the maritime industry as it considers both the physical and mental aspects of fatigue and is not time consuming to complete. Previously mentioned, there needs to be a greater demographic of workers onboard the vessels sampled in the research as each individual occupation onboard somehow contributes to the efficient functioning of the vessel.

To further increase participant compliance, a different distribution method of the research protocol may be more efficient. This could include the use of palm pilots or touch screen computers. Individuals may be more willing to comply with this technology which would not be as bulky as paper booklets which may be viewed as more paperwork. With advancing mobile technology and sufficient research funding, this protocol is attainable.

Finally, there also needs to be more qualitative research and focus groups conducted based on the discussion around seafarer fatigue and its indicators that includes all stakeholders in industry. Gaining further perspective of what workers and management consider indicators of fatigue in this industry could help bring more consensuses to the fatigue issue among different parties. This type of research could also help gain more insight into the specific underlying nature of factors identified in the current study, which could lead to even stronger development of fatigue mitigation programs for organizations.

CHAPTER 6 RECOMMENDATIONS AND CONCLUSIONS

The current study sought to identify the indicators that contribute to OOW fatigue through mixed multi-level linear analysis. Through the factors identified in this study, recommendations and best practices based on the results will be presented in this chapter. This will be followed by a concluding statement for the current study.

6.1 Recommendations

The most ideal recommendation to help alleviate officer fatigue on vessels would be the addition of more workers. The addition of workers would help ease the burden of work tasks such as paperwork and navigational watches. However, due to technological advances in the bridge and the increasing demand to optimize crew performance while minimizing crew numbers (Hetherington et al., 2006), an additional crew member may not always be viewed as feasible. Therefore, organizations need to focus on optimizing individual performance so the individual's ability to perform their required tasks is not compromised. One of the ways organizations can handle this concern is through the implementation of proper fatigue mitigation programs.

There is an identified need for organizations to properly address the issue of worker fatigue. Rhodes and Gil (2002) state that a traditional approach to fatigue mitigation by organizations usually only incorporates hours of work and rest regulations. Based on the findings of the current study, this is not a sufficient intervention method. An integrated approach to fatigue management needs to be considered that incorporates knowledge of the various fatigue factors. Therefore, a comprehensive fatigue management system should include, but not necessarily be limited to: the proper documentation of work and rest hours; incident and accident reports and investigations; stakeholder (not only employee) education and training; optimal workplace conditions; employee readiness for work, and suitable scheduling and rostering practices. Incorporating these aspects into a fatigue mitigation program enables companies to identify and understand, monitor, educate, schedule, counsel, and evaluate fatigue mitigation program components relevant to their organizational and employee needs (Rhodes & Gil, 2002). Ways that these components may be implemented within organizations is discussed next.

Proper fatigue education that is presented to various stakeholder levels (administration, owners, operators, managers, and workers) should emphasize the factors that lead to fatigue and how these factors can compromise safety (Rhodes & Gil, 2002). The training material should reference the different types of fatigue (physical, mental, etc.) and how they can be affected by fatigue factors such as motion, stress, and sleep quality. The implication of fatigue with regards to health, social, family, and dietary issues should also be discussed with mitigation strategies provided. These educational components need to be properly disseminated throughout an organization and amongst spouses and partners as they are also impacted by the irregular working hours and the seafaring life style (Rhodes & Gil, 2002).

Optimal workplace conditions should be provided to assist in the prevention of fatigue (Calhoun 2006; Grech et al., 2008; Rhodes & Gil, 2002). Specific to this study, this should include consideration to the design of the bridge and sleeping accommodations of the officers. Inspection should take place to ensure that proper levels of lighting, noise, temperature, and vibration are present in these areas. Sleeping accommodations should be placed away from sources of noise, and in instances when this cannot occur, noise levels should be alleviated with insulation and sound proofing material (Calhoun, 2006). Signage should also be posted around the sleeping quarter accommodation areas so that individuals onboard know to be quiet in areas where individuals are sleeping. In the cabin, seafarers should be able to screen out light and be provided with comfortable, suitable bedding that accounts for temperature changes and also for privacy and relaxation (Grech et al., 2008).

It is both the responsibility of the employer and the individual seafarer to ensure that they are in a sufficient state to perform their work and associated tasks (Rhodes & Gil, 2002). This requires accountability at both levels. For the employer, it is ensuring that there are proper rest and recovery cycles for seafarers while accounting for the other factors that may interfere with this time (e.g., extra work, social responsibilities), along with providing adequate workplace conditions to prevent fatigue. For the individual seafarer, it is ensuring that they use their time off in a responsible manner to have their social interactions but also obtain the necessary sleep and recovery. The individual seafarer should also be physically and mentally prepared to come to work, which can be reinforced through employee health and wellness programs.

Employers should consider having health and wellness initiatives in place for seafarers. This can include having a variety of nutritional food options readily available to seafarers, including the night watches when fresh food and snacks are hard to come by

(Calhoun, 2006). Educating seafarers on the health benefits of good nutritional practices and physical activity engagement at work and at home can help the individual seafarer think about how they prepare their body for work. Finally, companies can offer incentives such as discounted memberships for fitness clubs to encourage seafarers to be physically active during their time off as physical fitness appears to be important in helping workers cope with shift work (Harrington, 2001)

Rhodes and Gil (2002) note that a key factor in managing fatigue is in how the work periods are scheduled. Therefore, once management has received proper fatigue education training, they should be aware of the implications of an inadequate schedule. Suitable schedule and roistering practices should also be put into place to consider the various individual, economical, and operational factors but should also minimize the risk to an individual's health and safety (Rhode & Gils, 2002). These rosters and scheduling should be predictable because as mentioned in the study, unpredictability due to uncertainty surrounding working hours can be stressful.

6.2 Conclusion

Muscio (1921) referenced over 90 years ago that fatigue should be abolished from scientific discussion and the attempts to test it due to its ambiguity. While it is apparent that fatigue is ubiquitous in nature, this abolishment has not occurred as research into understanding its indicators continues to advance and improve. An example of this is found within the current study's use of an analysis method that can allow for both individual comparisons, accounting for the hierarchical structure of the maritime industry, thus providing further insight into the fatigue phenomena.

As operations continue to move further north, in harsher conditions, and in some situations deal with cases of piracy, it has never become more important to understand the human element in various maritime operations. The current study sought to explore this element in relation to fatigue indicators. Stakeholders in academia and industry need to continue forward with the fatigue discussion and collaborative research to devise solutions to best optimize seafarer performance. The current study addresses some of these factors, but there is still much work left to be completed.

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Appendix A: Common Sea Watch Systems

6 hours on, 6 hours off watch system rotation																								
Second Mate	On Watch																							
Third Mate	Off Watch							On Watch					Off Watch					On Watch						
Time of Day	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300

4 hours on, 8 hours off watch system rotation																								
Chief Mate	Off Watch				On Watch				Off Watch				Off Watch				On Watch				Off Watch			
Second Mate	On Watch				Off Watch				Off Watch				On Watch				Off Watch				Off Watch			
Third Mate	Off Watch				Off Watch				On Watch				Off Watch				Off Watch				On Watch			
Time of Day	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300

Legend		
	(hatched)	Off Watch
	(dark)	On Watch

Appendix B: Pre-Voyage Questionnaire

Background on the research:

As the Canadian shipping industry continues to prosper and expand, retaining healthy employees to work in the industry will be critical. However, it has been identified that worker fatigue is a health and safety issue in the shipping industry. The implications of worker fatigue can result in compromised individual and operational safety, with potentially disastrous consequences such as financial loss, environmental damage, or even loss of life. With these possible outcomes, research in understanding the risk factors that may contribute to fatigue in this industry has become of significant importance. With limited research conducted in this area in Canada, the purpose of the current research is to examine the risk factors associated with self-reported fatigue by officers working in the Canadian shipping sector. Officers of the watch have been identified as the target participants for this study as they are required to perform various tasks while meeting high operational demands. Obtaining deck officers' perspective of what may contribute to fatigue in their work environment will help guide researchers and industry stakeholders to develop the measures needed to mitigate work-related fatigue in this safety critical industry.

Outline for Research:

Thank you for taking the time to consider participation in this research. Before explaining the research procedure there are a couple of important points:

- You will never be individually identified for partaking in this research, nor will the company that you work for. All the information that you forward to the research team in the questionnaires will be kept confidential and will not be shared with your employer.

- To obtain the best results from this research, I ask that you complete "the before shift" and "after shift" questionnaires as close to the beginning and immediately after your watch as possible to capture the best possible data.

The Research Procedure:

The research package includes 2 booklets (1) *The consent form and pre-voyage questionnaire* (2) *The logbook questionnaire:*

1) The blue booklet: Contains 2 consent forms and a pre-voyage questionnaire

- This booklet is to be completed prior to leaving for a work rotation at sea and takes approximately 25 minutes to complete. It only needs to be completed once.

A. **The Consent Form:**

- When you immediately open the booklet you will first see a consent form. This is to ensure your participation and understanding of the research requirements. Please read through and sign the consent form that will be kept in the pre-voyage questionnaire for the researcher. There is also an additional copy that you can remove for you to keep for your personal records.

B. **The Pre-voyage Questionnaire:**

- This questionnaire needs to be completed prior to boarding the vessel for a sea-going trip. You can complete this in your spare time at home. When you finish this questionnaire, you can put it in the addressed envelope and please mail it back to the research team.

2) The black logbook: Contains multiple copies of the before shift questionnaire and after shift questionnaire dependent on the length of your sea going trip

- These short questionnaires are to be completed **before** and **after** each watch everyday while on one rotation at sea:

A. **The Before Shift Questionnaire:**

- This questionnaire is to be completed prior to watch. This questionnaire takes approximately 5 minutes to complete.

B. **The After Shift Questionnaire:**

- This questionnaire is to be completed immediately after finishing your current shift. This questionnaire takes approximately 5 minutes to complete.

Again, thank you for considering this research. Please do not hesitate to contact me with any further questions.

Sincerely,

Laura Critch,

MSc Student (Kinesiology), Memorial University of Newfoundland

709-685-1202 (Cell)

709-864-3138 (Office)

lcritch@mun.ca (e-mail)

Consent to Take Part in Research

TITLE: A human factors approach to understanding the factors that contribute to officer fatigue in the Atlantic Canada shipping industry.

INVESTIGATOR(S): Dr. Scott MacKinnon, Dr. Angela Loucks-Atkinson, Laura Critch, Dr. Jim Parsons

You have been invited to take part in a research study. It is up to you to decide whether to be in the study or not. Before you decide, you need to understand what the study is for, what risks you might take and what benefits you might receive. This consent form explains the study.

The researchers will:

- **discuss the study with you**
- **answer your questions**
- **keep confidential any information which could identify you personally**
- **be available during the study to deal with problems and answer questions**

If you decide not to take part or to leave the study it will not affect your working status

1. **Introduction/Background:**

   Fatigue in the shipping industry has become a recognized health and safety concern. As an industry that places high expectations on officers, it is important to understand the risk factors that contribute to officer fatigue as they can result in reduced officer performance. A reduction in performance from fatigue could ultimately lead to individual health problems, environmental damage and economic loss from accidents and injury. Previous studies conducted in the area have shown risk factors for fatigue to include high work stress, job demand, shorter tour length and poor sleep quality. There is little research conducted in Atlantic Canada to support that the same risk factors exist for officers involved in industry here. This can affect the measures taken by industry regulators and companies to deal with fatigue in this industry. By obtaining information on how officers of the watch in Atlantic Canada identify risk factors in their work that can contribute to fatigue, appropriate measures can be introduced. This can help reduce fatigue and decrease the risk of accident and injury in this industry.

2. **Purpose of study:**

   The purpose of this study is to examine the risk factors associated with self-reported officer fatigue in the Atlantic Canada shipping industry using a subjective questionnaire method.

3. **Description of the study procedures and tests:**

If you choose to participate, an investigator will first explain the purpose of this study to you. You will be required to complete an initial questionnaire at home that takes approximately 30 minutes to fill out. This questionnaire contains questions about your work at sea, your life at home during leave and your individual well-being. Upon completion of this questionnaire, you can use the envelope that accompanied the questionnaire and mail it back to the investigator. The next time you will be asked to participate in this study will be during a work rotation at sea. Here you will be asked to complete two separate questionnaires, one at the beginning and another at the end of your watch each day while you are at work. The "before watch" questionnaire is to be completed before your watch and includes questions examining sleep patterns, eating behaviors, alcohol and caffeine consumption, medication, smoking and perceived fatigue before a watch. This will take approximately 5 minutes to complete. Upon completing your watch, you will be asked to fill out an "after watch" questionnaire. This questionnaire examines with your health behaviors during your watch and asks questions about your breaks during watch, eating behaviors, caffeine consumption, medication you may be/are taking, your workload during the watch, the work environment, hazards in the workplace and your perceived fatigue after the watch. This will take approximately 10 minutes to complete. Once you have finished a work rotation and sea and complete the logbook questionnaire, it can be returned to the investigators for analysis.

4. **Length of time:**

You will be expected to complete the first questionnaire at home that will take approximately 30 minutes of your time. While working at sea, you will be expected to complete the "before watch" questionnaire and "after watch" questionnaire for each watch and that will take approximately 5-10 minutes of your time for each questionnaire.

5. **Possible risks and discomforts:**

The possibility of risk is minimized because there are limited questions in the questionnaire that would individually identify you, protecting your confidentiality. Only study investigators will have access to your questionnaire data once it is collected, reducing the possibility of risk to you as well.

6. **Benefits:**

It is not known whether this study will benefit you.

7. **Liability statement:**

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form, you do not give up your legal rights. Researchers or agencies involved in this research study still have their legal and professional responsibilities.

8. What about my privacy and confidentiality?

Protecting your privacy is an important part of this study. Every effort to protect your privacy will be made. However it cannot be guaranteed. For example we may be required by law to allow access to research records. As neither investigator is available to collect your questionnaire data while at sea, you are responsible for keeping your questionnaire secure during this time period. We ask that you the take the necessary steps to keep the questionnaire in a safe and secure place that can only be accessed by you, protecting your confidentiality.

When you sign this consent form you give us permission to

- Collect information from you
- Share information with the people conducting the study
- Share information with the people responsible for protecting your safety

Access to records

The members of the research team will see study records that identify you by name. Other people may need to look at the study records that identify you by name. This might include the research ethics board. You may ask to see the list of these people. They can look at your records only when one of the research team is present.

Use of records

The research team will collect and use only the information they need for this research study.

This information will include your

- birth year
- sex
- medications
- information from study questiomaires

Your name and contact information will be kept secure by the research team in Newfoundland and Labrador. It will not be shared with others without your permission. Your name will not appear in any report or article published as a result of this study.

Information collected for this study will kept for 5 years.

If you decide to withdraw from the study, the information collected up to that time will continue to be used by the research team. It may not be removed. This information will only be used for the purposes of this study

Information collected and used by the research team will be stored by Dr. MacKinnon and he is the person responsible for keeping it secure.

Your access to records

You may ask Dr. MacKinnon to see the information that has been collected about you.

9. Questions:

If you have any questions about taking part in this study, you can meet with the investigator who is in charge of the study at this institution. That person is Dr. Scott MacKinnon (864-6936 or smackinn@mun.ca)

Or you can talk to someone who is not involved with the study at all, but can advise you on your rights as a participant in a research study. This person can be reached through:
Office of the Human Investigation Committee (HIC) at 709-777-6974 or
Email: hic@mun.ca

After signing this consent you will be given a copy.

Signature Page

Study title: A human factors approach to understanding the factors that contribute to officer fatigue in the Atlantic Canada shipping industry.

Name of principal investigator:
Scott N. MacKinnon, PhD

To be filled out and signed by the participant:

	Please check as appropriate:	
I have read the consent	Yes { }	No { }
I have had the opportunity to ask questions/to discuss this study.	Yes { }	No { }
I have received satisfactory answers to all of my questions.	Yes { }	No { }
I have received enough information about the study.	Yes { }	No { }
I have spoken to Dr. MacKinnon and he has answered my questions	Yes { }	No { }
I understand that I am free to withdraw from the study	Yes { }	No { }
• at any time	Yes { }	No { }
• without having to give a reason	Yes { }	No { }
• without affecting my future worker status	Yes { }	No { }
I understand that it is my choice to be in the study and that I may not benefit.	Yes { }	No { }
I agree to take part in this study.	Yes { }	No { }

______________________________ ______________________
Signature of participant Date

______________________________ ______________________
Signature of witness (if applicable) Date

To be signed by the investigator or person obtaining consent

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

______________________________ ______________________
Signature of investigator/person obtaining consent Date

Telephone number: ______________________

ID___________

Section 1: Worker Demographics

1.1 What is your birth year? __________year

1.2 What is your sex?: *(please tick one box)* □ Male □ Female

1.3 What is your current marital status?: *(please tick one box)*

□ Single □ Living with partner □ Married
□ Divorced □ Separated □ Widowed

1.4 What is the highest level of education you have completed? *(please tick one box)*

□ No schooling □ Without high school diploma □ Some post secondary
□ College or trade certification □ University Degree □ Other_____________

1.5 In what rank or position do you serve on the current vessel? *(please tick one box)*

□ Captain □ First Officer □ Second Officer
□ Third Officer □ Other *(please explain)* ____________________

1.6 What is your present area of operation? *(please tick one box)*

□ Offshore □ Short sea & Coastal □ Other *(please specify)* ___________

1.7 Approximately how many years have you worked at sea? ____________ year (s)

1.8 What is your nationality? ______________

1.9 How long will you have been on this vessel when your current contract ends ______ month(s) ______ week(s) ______ day(s)

1.10 How long were you on your last ship? ______ month(s) ______ day(s)

1.11 What is the work/leave system onboard? *(please tick one box)*

□ 6 weeks on, 6 weeks off □ 4 weeks on, 4 weeks off □ 3 weeks on 3 weeks off
□ 3 weeks on 3 weeks off □ 2 weeks on 2 weeks off □ 1 week on, 1 week off
□ Upon project completion
□ Other *(please specify)*___________________

1.12 On a typical day, what is your watch/duty schedule? *(please tick one box)*

□ 12 hours on, 12 hours off □ 6 hours on, 6 hours off □ 4 hours on, 8 hours off
□ 4 hours on, 4 hours off
□ Other *(please specify)* ___________________

ID_________

1.13 What hours do you stand watch?

□ 00-04	□ 00-06	
□ 04-08	□ 06-12	□ Other *(please specify)* ____________________
□ 08-12	□ 12-18	
□12-16	□ 18-24	
□ 16-20	□ 20-24	

1.14 Please check as many of the following you need to properly describe your work :

□ Navigation	□ Paperwork	□ Chartwork
□ Watchkeeping	□ Supervising Other Crew Members	□ Vessel Management
□ Equipment Maintenance	□ Supervising Maintenance	□ Cargo Monitoring

1.15 How many hours a day do you work (when not on watch) on additional duties?

____

1.16 Do you think the number of hours you work creates a personal health and safety risk? *(please tick one box)*

□ Yes □ No □ Sometimes

1.17 Do you think the number of hours you work creates a risk to the safe operations onboard the ship? *(please tick one box)*

□ Yes □ No □ Sometimes

1.18 Over your career, do you think your working hours have: *(please tick one box)*

□ Increased □ Decreased □ Stayed the same

The following questions ask about your work environment. For each question, please circle one answer from 1-5 (1=often; 5= almost never) for each question that best describes your work.

		Often	Sometimes	Seldom	Never	Almost Never
1.19	**Do you have unpredictable working hours?**	1	2	3	4	5
1.20	**Does your job ever expose you to breathing fumes, dusts, or other potentially harmful substances?**	1	2	3	4	5
1.21	**Does the level of back ground noise in your work disturb your concentration?**	1	2	3	4	5
1.22	**Does the level of vibration in your workplace affect your performance?**	1	2	3	4	5
1.23	**Do you experience feelings of nausea brought on by motion effects?**	1	2	3	4	5

ID_______

In these next questions we would like to know whether or not you agree with statements about your work. Please circle one answer from 1-5 (1= no; 5= always) about your level of agreement

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1.24 I have constant time pressure due to a heavy workload	1	2	3	4	5
1.25 I have many interruptions and disturbances in my job	1	2	3	4	5
1.26 I have a lot of responsibility in my job	1	2	3	4	5
1.27 I am often under pressure to work overtime	1	2	3	4	5
1.28 I feel stressed because of my job	1	2	3	4	5

Section 2: Port Information

2.1 During a typical tour of duty, how many port calls do you make? ________________

When you are in port do you: *(please tick one answer for each question)*

	Yes	No	Sometimes
2.2 Work the same hours at sea?	□	□	□
2.3 Work more hours than at sea?	□	□	□
2.4 Obtain time to go ashore?	□	□	□
2.5 Go ashore in off duty hours?	□	□	□
2.6 Experience a heavier workload compared to at sea?	□	□	□

2.7 Please use the space below to list the duties that you are required to perform while the vessel is in port, if different from duties at sea. If the duties are not different at port than at sea, please tick N/A (not applicable):

N/A □

____

____

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Section 3: Fatigue At Sea

Fatigue can be defined as, "A state of feeling tired, weary or sleepy that results from prolonged mental or physical work, extended periods of anxiety, exposure to harsh environments, or loss of sleep. The result of fatigue is impaired performance and diminished alertness" (International Maritime Association)

Please circle one answer from 1-5 for each question (1 = very; 5 = not at all), about the extent you experience the following symptoms of fatigue while at sea.

		Very				Not At All
3.1	**Confusion**	1	2	3	4	5
3.2	**Tired**	1	2	3	4	5
3.3	**Poor Quality Sleep**	1	2	3	4	5
3.4	**Depression**	1	2	3	4	5
3.5	**Tension**	1	2	3	4	5
3.6	**Loss of Concentration**	1	2	3	4	5

3.7 How many fatigue related near misses or accidents do you believe have been your responsibility? *(please tick one box)*

□ None □ Less than 5 □ More than 5

3.8 Do you ever find yourself napping while on watch? *(please tick one box)*

□ Yes □ No □ Sometimes

Section 4: Information About Your Sleep

4.1 What is your ideal length of sleep? ______________________________ hour (s)

4.2 What time do you normally go to bed at home? *(please use a 24 clock)* __________

While on board the vessel, how often do you?
(Please circle one number from 1-4 (1= not at all; 4 = almost always) for each question)

		Not At All			Almost Always
4.3	**Have difficulty in falling asleep**	1	2	3	4
4.4	**Have difficulty in staying asleep**	1	2	3	4

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		Not At All			Almost Always
4.5	Wake up during sleep	1	2	3	4
4.6	Have difficulty getting up	1	2	3	4
4.7	Have restless or disturbed sleep	1	2	3	4
4.8	Disturb the sleep of other people	1	2	3	4
4.9	Wake up confused, disorientated, irritable	1	2	3	4

How much do the following factors impact the quality of your sleep while at sea?
(Please circle a number from 1-4 (1= not at all; 5 = almost always) for each question)

		Not At All				Almost Always
4.10	Noise	1	2	3	4	5
4.11	Heat or Cold	1	2	3	4	5
4.12	Quality of Bed	1	2	3	4	5
4.13	Light	1	2	3	4	5
4.14	Ship Motion	1	2	3	4	5
4.15	Other People	1	2	3	4	5
4.16	Being on Call	1	2	3	4	5

4.17 Do you share a cabin? *(please tick one box)*

□ Yes □ No

4.18 Is it possible for you to screen out daylight in your cabin? *(please tick one box)*

□ Yes □ No

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Section 5: Health and Lifestyle While on Leave

5.1 Which of the following are your most common health complaints? What would you say is your most common health complaint? *(please tick one box)*

□ Viral infections/colds/sore throats □ Joint/muscular pain □ Digestive disorders

□ Cardiovascular disorders □ Headaches □ Psychological disorders

□ Skin complaints □ Chronic illness (e.g., asthma/diabetes)

□ Other (non-categorical) □ N/A

Physical Activity While on Leave

We are interested in knowing how often you participate in physical activity. Considering a typical 7 (seven) day period (a week), how many times on average do you do the following kinds of physical activity for more than 15 minutes during your free time. Please write your response in the corresponding box.

5.2 Strenuous Exercise (Heart beats rapidly)
(e.g., running, jogging, hockey, snowshoeing, soccer, squash, basketball, cross country skiing, judo, vigorous swimming, vigorous long distance bicycling) ☐

5. 3 Moderate Exercise (Not exhausting; heart beats quickly but you can still continue a conversation)
(e.g., fast walking, shovelling snow, canoeing, kayaking, tennis, easy bicycling, badminton, easy swimming, down-hill skiing, popular and folk dancing) ☐

5.4 Mild Exercise (Minimal effort)
(e.g., curling, yard work, yoga, archery, fishing from river bank, bowling, horseshoes, golf, snowmobiling, easy walking) ☐

5.5 Considering a 7-day period (a week), how often do you engage in any regular physical activity long enough to work up a sweat (heart beats rapidly)? *(please tick one box)*

□ Often □ Sometimes □ Never/ Rarely

5.6 Do you smoke cigarettes (i.e. NOT cigars/pipe)? *(please tick one box)*

□ Yes □ No

5.7 How many cigarettes do you smoke per day? ___________________________

5.8 Do you consume alcohol while on leave? □ Yes □ No

5.9 How much alcohol would you typically consume *per week* while on leave? ________________

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Fatigue on Leave

Please circle one answer from 1 – 5 (1 = not at all; 5 = very much) for each question as to what extent you experience the following symptoms of fatigue while on leave.

		Not At All				Very Much
5.10	Confusion	1	2	3	4	5
5.11	Tired	1	2	3	4	5
5.12	Poor Quality Sleep	1	2	3	4	5
5.13	Depression	1	2	3	4	5
5.14	Tension	1	2	3	4	5
5.15	Loss of Concentration	1	2	3	4	5

Section 6: Your General Well-Being

GHQ

These questions are about how you have been feeling in the last few months in general. Please try to answer ALL the questions by circling one answer for each line.

HAVE YOU RECENTLY:

6.1	**Been able to concentrate on whatever your doing**	Better than usual	Same as usual	Less than usual	Much less than usual
6.2	**Lost much sleep over worry?**	Not at all	Same as usual	Rather more than usual	Much more than usual
6.3	**Felt that you are playing a useful part in things?**	More so than usual	Same as usual	Less useful than usual	Much less useful
6.4	**Felt capable of making decisions about things?**	More so than usual	Same as usual	Less so than usual	Much less capable
6.5	**Felt constantly under strain?**	Not at all	No more than usual	Rather more than usual	Much more than usual
6.6	**Felt that you couldn't overcome your difficulties?**	Not at all	No more than usual	Rather more than usual	Much more than usual
6.7	**Been able to enjoy your normal day-to-day activities?**	More so than usual	Same as usual	Less so than usual	Much less than usual
6.8	**Been able to face up to your problems?**	More so than usual	Same as usual	Less able than usual	Much less able
6.9	**Been feeling unhappy and depressed?**	Not at all	No more than usual	Rather more than usual	Much more than usual

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6.10	**Been losing confidence in yourself?**	Not at all	No more than usual	Rather more than usual	Much more than usual
6.11	**Been thinking of yourself as a worthless person?**	Not at all	No more than usual	Rather more than usual	Much more than usual
6.12	**Been feeling reasonably happy, all things considered?**	More so than usual	No more than usual	Less so than usual	Much less than usual

Health Survey (SF-36)

6.13 In general, would you say your health is: *(please circle one answer)*

Excellent Very Good Good Fair Poor

6.14 Compared to one year ago, how would you rate your health in general **now**? *(please tick one box)*

Much better now than one year ago □

Somewhat better now than one year ago □

About the same as one year ago □

Somewhat worse now than one year ago □

Much worse now than one year ago □

The following questions are about activities you might do during a typical day. Does **your health now limit you** in these activities? If so, how much? *(Circle one number for each question)*

	Activities	Yes, limited a lot	Yes, limited a little	No, not limited at all
6.15	**Vigorous activities**, such as running, lifting heavy objects, participating in strenuous sports.	1	2	3
6.16	**Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf.	1	2	3
6.17	Lifting or carrying groceries.	1	2	3
6.18	Climbing **several** flights of stairs.	1	2	3
6.19	Climbing **one** flight of stairs	1	2	3
6.20	Bending, kneeling, or stooping.	1	2	3
6.21	Walking **more than a mile.**	1	2	3

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		Yes, limited a lot	Yes, limited a little	No, not limited at all
6.22	**Walking half a mile.**	1	2	3
6.23	**Walking one hundred yards.**	1	2	3
6.24	Bathing or dressing yourself.	1	2	3

During the **past 4 weeks** have you had any of the following problems with your work or other regular daily activities **as a result of your physical health?** *(Circle one number for each question)*

6.25 Cut down on the **amount of time** you spent on work or other activities.	Yes	No
6.26 **Accomplished less** than you would like.	Yes	No
6.27 Were limited in the **kind of work** or other activities.	Yes	No
6.28 Had **difficulty** performing the work or other activities (for example, it took extra effort)	Yes	No

During the **past 4 weeks**, have you had any of the following problems with your work or other regular daily activities **as a result of any emotional problems** (such as feeling depressed or anxious)? *(Circle one number for each question)*

6.29 Cut down on the **amount of time** you spent on work or other activities.	Yes	No
6.30 **Accomplished less** than you would like.	Yes	No
6.31 Didn't do work or other activities as **carefully** as usual.	Yes	No

6.32 During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups? *(please circle one answer)*

Not at all   Slightly   Moderately   Quite a bit   Extremely

6.33 How much **bodily** pain have you had during the **past 4 weeks**? *(please circle one answer)*

None   Very mild   Mild   Moderate   Severe   Very Severe

6.34 During the **past 4 weeks**, how much did **pain** interfere with your normal work (including both work outside the home and housework)? *(please circle one answer)*

Not at all   A little bit   Moderately   Quite a bit   Extremely

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These questions are about how you feel and how things have been with you **during the past 4 weeks**. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks: *(Circle one number for each question)*

		All of the time	Most of the time	A good bit of the time	Some of the time	A little of the time	None of the time
6.35	**Did you feel full of life?**	1	2	3	4	5	6
6.36	**Have you been a very nervous person?**	1	2	3	4	5	6
6.37	**Have you felt so down in the dumps that nothing could cheer you up?**	1	2	3	4	5	6
6.38	**Have you felt calm and peaceful?**	1	2	3	4	5	6
6.39	**Did you have a lot of energy**	1	2	3	4	5	6
6.40	**Have you felt downhearted and low?**	1	2	3	4	5	6
6.41	**Did you feel worn out?**	1	2	3	4	5	6
6.42	**Have you been a happy person?**	1	2	3	4	5	6
6.43	**Did you feel tired?**	1	2	3	4	5	6

6.44 During the past 4 weeks, how much of the time has your **physical health or emotional problems** interfered with your social activities (like visiting with friends, relatives, etc.)? *(please circle one answer)*

All the time   Most of the time   Some of the time   A little of the time   None of the time

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How TRUE or FALSE is each of the following statements for you? *(Circle one number for each question)*

		Definitely True	Mostly True	Don't know	Mostly false	Definitely False
6.45	I seem to get ill more easily than other people	1	2	3	4	5
6.46	I am as healthy as anybody I know	1	2	3	4	5
6.47	I expect my health to get worse	1	2	3	4	5
6.48	My health is excellent	1	2	3	4	5

Physical Mental Fatigue Scale (Adapted from Pietrowsky et al., 2008)
We are interested in knowing about your level of fatigue **AT THE PRESENT MOMENT**. Please circle one answer from 1-5 (1 being very much so; 5 being not at all) for each question.

	Question:	Very Much				Not At All
6.49	My concentration is very bad	1	2	3	4	5
6.50	I am having problems thinking clearly	1	2	3	4	5
6.51	I have less strength in my muscles	1	2	3	4	5
6.52	I am very stimulated	1	2	3	4	5
6.53	I feel very bored	1	2	3	4	5
6.54	I need to rest more	1	2	3	4	5
6.55	I feel physically very strained	1	2	3	4	5
6.56	I am lacking energy	1	2	3	4	5
6.57	I feel mentally very strained	1	2	3	4	5
6.58	I feel sleepy or drowsy	1	2	3	4	5

Thank you for taking the time to complete this questionnaire!

Appendix C: Before Watch Questionnaire

Please try to complete this questionnaire before your watch begins

7.1 Date: _______dd_______m________yy

7.2 Current time: ***(please use a 24 hour clock)*** ___________

7.3 Projected watch length (hours): _____________

7.4 In how many minutes will your watch begin? ______________

7.5 Vessel Status: □ In port □ At sea

7.6 How many units of alcohol did you consume yesterday?
(1 bottle of beer/ 1 glass wine/ 1 measured shot = 1 unit) ______________ Units

Please complete with respect to the ***main*** sleep period you have had today ***(please use a 24 hour clock)***

7.7	Time you went to bed:	__________________
7.8	Approximate time you fell asleep	__________________
7.9	Time you woke up:	__________________
7.10	How many times did you wake up during the sleep period?	__________

7.11 Please tick ***ONE*** of the following boxes to indicate whether last sleep was:

□ About normal for you? □ Shorter than normal? □ Longer than normal?

Please rate your sleep from 1-5 for each question (1= optimal; 5= problematic)

		Optimal				Problematic
7.12	Ease of falling asleep	1	2	3	4	5
7.13	Ease of arising	1	2	3	4	5
7.14	Was this sleep period sufficient?	1	2	3	4	5
7.15	How deep was your sleep	1	2	3	4	5

Eating Patterns

7.16	Did you eat a meal before watch?	□ Yes	□ No
7.17	What time did you eat? _______________		□ N/A
7.18	What did you have to eat? ____________________________		

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How many servings of the following drinks have you had since the end of your last watch?				
7.19	**Caffeinated Beverages** (Coffee, tea, pepsi/coke, energy drinks)	□ None □ 3 servings	□ 1 serving □ 4 servings	□ 2 servings □ 5+ servings
7.20	**Decaffeinated Beverages** (Decaffeinated coffee, decaffeinated tea, juice, caffeine free pop)	□ None □ 3 servings	□ 1 serving □ 4 servings	□ 2 servings □ 5+ servings

7.21 Which of the following medications have you taken in the last 12 hours?

□ None
□ Cardiovascular
□ Pain relief/anti-inflammatory
□ Anti-depressants/tranquilliser
□ Vitamins/Natural supplements
□ Other

7.22 How many tobacco products have you smoked since your last watch? _____________

Physical Mental Fatigue Scale (Adapted from Pietrowsky et al., 2008)

We are interested in knowing about your level of fatigue **AT THE PRESENT MOMENT**. Please circle one answer from 1-5 (1 being very much so; 5 being not at all) for each question.

	Question:	**Very Much**				**Not At All**
7.23	**My concentration is very bad**	1	2	3	4	5
7.24	**I am having problems thinking clearly**	1	2	3	4	5
7.25	**I have less strength in my muscles**	1	2	3	4	5
7.26	**I am very stimulated**	1	2	3	4	5
7.27	**I feel very bored**	1	2	3	4	5
7.28	**I need to rest more**	1	2	3	4	5
7.29	**I feel physically very strained**	1	2	3	4	5
7.30	**I am lacking energy**	1	2	3	4	5
7.31	**I feel mentally very strained**	1	2	3	4	5
7.32	**I feel sleepy or drowsy**	1	2	3	4	5

Appendix D: After Watch Questionnaire

ID__________

After Shift Questionnaire

Please try to complete this questionnaire as soon as your watch ends

8.1 Date: ______dd_______m________yy

8.2 Current time (use a 24 hour clock): ___________

8.3 Actual Watch Length:__________

8.4 Vessel Status: □ In port □ At sea

About Today's Work

The following questions ask you about today's work please state what you did and when.

8.5 If you ate during this watch, what time did you have your meal? *(please use a 24 hour clock)*

____

8.6 What did you have to eat on this watch? ____

About Your Breaks

	8.7 What time did you take.... *(please use a 24 clock)*		**8.8 Length of Break (in minutes)**		**8.9 Type of Break (Eg. coffee, cigarette)**	
8.7 a)	Break # 1?		**8.8 a)**		**8.9 a)**	
8.7 b)	Break # 2?		**8.8 b)**		**8.9 b)**	
8.7 c)	Break # 3?		**8.8 c)**		**8.9 c)**	

8.10 Were you able to decide when you took these breaks? □ Yes □ No

How many servings of the following drinks have you had during this watch?				
8.11	**Caffeinated Beverages** (Coffee, tea, pepsi/coke, energy drinks)	□ None □ 3 servings	□ 1 serving □ 4 servings	□ 2 servings □ 5+ servings
8.12	**Decaffeinated Beverages** (Decaffeinated coffee, decaffeinated tea, juice, caffeine free pop)	□ None □ 3 servings	□ 1 serving □ 4 servings	□ 2 servings □ 5+ servings

8.13 How many tobacco products have you smoked during this watch? ______________

Workload

8.14 Could you please indicate on the scale below the amount of physical effort you have put into this watch today (1 = little or no effort, 7 = maximum effort)

1	2	3	4	5	6	7
Little or no effort						Maximum physical physical effort

ID____________

8.15 Could you please indicate on the scale below how physically demanding you felt this watch was (1 = not at all demanding, 7 = extremely demanding)

1	2	3	4	5	6	7
Not at all physically demanding						Extremely physically demanding

8.16 Could you please indicate on the scale below the amount of mental effort you have put into this watch today? (1 = little or no effort, 7= maximum effort)

1	2	3	4	5	6	7
Little or no effort						Maximum mental mental effort

8.17 Could you please indicate on the scale below how mentally demanding you felt this watch to be? (1 = not at all demanding, 7= extremely demanding)

1	2	3	4	5	6	7
Not at all mentally demanding						Extremely mentally demanding

The following questions address work-related issues during this past watch. For each question please tick one box for each question that best describes today's watch.

		Not at all	**Mildly**	**Moderately**	**Extremely**
8.18	I was exposed to dusts or other potentially harmful substances	□	□	□	□
8.19	I felt the air temperature was to hot/cold to work effectively	□	□	□	□
8.20	I felt I had too much work to do today	□	□	□	□
8.21	I felt that I had good support from fellow coworkers if I needed it today	□	□	□	□
8.22	How stressful did you find your job today?	□	□	□	□
8.23	Did you have a choice in deciding what you did at work or how you did at work today?	□	□	□	□
8.24	Was your job boring today?	□	□	□	□

	Very good	**Good**	**Fair**	**Bad**	**Very Bad**
8.25) Describe your general health during the shift.	□	□	□	□	□

ID___________

Your Environment

(Please circle one number for each question)

8.26 Sea State

Calm ... *Hurricane Force*

1 2 3 4 5 6 7 8 9 10 11 12

8.27 Motion of vessel

Minimal ... *Extreme*

1 2 3 4 5 6 7 8 9 10

8.28 Noise

Very Quiet ... *Intense*

1 2 3 4 5 6 7 8 9 10

Physical Mental Fatigue Scale (Adapted from Pietrowsky et al., 2008)
We are interested in knowing about your level of fatigue **AT THE PRESENT MOMENT** (1 being very much so; 5 being not at all). Please circle one answer for each question.

	Question:	Very Much				Not At All
8.29	My concentration is very bad	1	2	3	4	5
8.30	I am having problems thinking clearly	1	2	3	4	5
8.31	I have less strength in my muscles	1	2	3	4	5
8.32	I am very stimulated	1	2	3	4	5
8.33	I feel very bored	1	2	3	4	5
8.34	I need to rest more	1	2	3	4	5
8.35	I feel physically very strained	1	2	3	4	5
8.36	I am lacking energy	1	2	3	4	5
8.37	I feel mentally very strained	1	2	3	4	5
8.38	I feel sleepy or drowsy	1	2	3	4	5