INTERNATIONAL MARITIME ORGANIZATION

E

4 ALBERT EMBANKMENT
LONDON SE1 7SR
Telephone: +44 (0)20 7735 7611 Fax: +44 (0)20 7587 3210

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GUIDELINES ON FATIGUE

1 The Maritime Safety Committee, at its seventy-first session (19 to 28 May 1999), considered the issue of human fatigue and agreed to develop practical guidance to provide appropriate information on fatigue to all parties concerned.

2 Consequently, at its seventy-fourth session (30 May to 8 June 2001), the Committee approved MSC/Circ.1014 on *Guidance on fatigue mitigation and management*.

3 The Committee, at its ninety-fourth session (17 to 21 November 2014), agreed to undertake a revision of the *Guidance on fatigue mitigation and management* and instructed the Sub-Committee on Human Element, Training and Watchkeeping (HTW) to conduct the review.

4 Accordingly, the Committee, at its 100th session (3 to 7 December 2018), approved the annexed *Guidelines on fatigue*, finalized by the HTW Sub-Committee, at its fifth session (16 to 20 July 2018).

5 Member States are invited to:

.1 bring the Guidelines to the attention of their maritime Administrations and all stakeholders, including seafarers, companies, naval architects/ship designers and training providers;

.2 use the Guidelines as a basis for disseminating information on fatigue (for example by means of pamphlets, video training modules, seminars and workshops); and

.3 take the Guidelines into consideration when determining minimum safe manning.

6 Companies are strongly urged to take the issue of fatigue into account when developing, implementing and improving safety management systems under the ISM Code.

7 This circular supersedes MSC.1/Circ.1014 on *Guidance on fatigue mitigation and management*, approved on 12 June 2001.

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ANNEX

GUIDELINES ON FATIGUE

INTRODUCTION

1 For the purpose of the Guidelines, the following definition for fatigue is used:

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

2 Fatigue is a hazard because it may affect a seafarer's ability to do their job effectively and safely. Importantly, fatigue affects everyone regardless of skill, knowledge and training. The effects of fatigue can be particularly dangerous in the transportation sector, including the shipping industry. All stakeholders should be alert to the factors which may contribute to fatigue, and make efforts to mitigate and manage the risks posed by fatigue.

3 Effectively dealing with fatigue in the maritime environment requires a comprehensive and holistic approach that recognizes ship design, and the roles and responsibilities of all stakeholders in the mitigation and management of fatigue. An effective fatigue management strategy begins with determining operational workload requirements and matching onboard manning levels and onshore support resources, combined with efficient management of workload and hours of work and rest on board the ship. There is no one-system approach to addressing fatigue, but there are certain principles that should be addressed in order to gain the knowledge and the understanding to manage this human element issue.

Objective

4 The Organization has developed these Guidelines to assist all stakeholders in better understanding their roles and responsibilities in mitigating and managing the risk of fatigue.

5 The Guidelines provide information on the causes and consequences of fatigue, and the risks it poses to the safety and health of seafarers, operational safety, security and protection of the marine environment. It has been prepared to assist all stakeholders in contributing to the mitigation and management of fatigue.

Organization

6 The Guidelines are composed of modules each devoted to an interested party. The modules are as follows:

.1	Module 1	Fatigue
.2	Module 2	Fatigue and the company
.3	Module 3	Fatigue and the seafarer
.4	Module 4	Fatigue, awareness and training
.5	Module 5	Fatigue and ship design
.6	Module 6	Fatigue, the Administration and port State Authorities
.7	Appendix 1	Examples of sleep and fatigue monitoring tools
.8	Appendix 2	Example of a fatigue event report information

How to use these modules

7 The modules are all interrelated; it is recommended that all parties become familiar with module 1, which contains general information on fatigue. It may be beneficial if the reader (interested party) becomes familiar with modules other than the immediately applicable one.

8 These guidelines should be taken into consideration when:

.1 developing, implementing and maintaining safety management systems under the ISM Code;

.2 promoting fatigue mitigation and management;

.3 promoting awareness of the causes and consequences of fatigue and developing and delivering training programmes and courses;

.4 conducting casualty or accident/incident investigations; and

.5 preparing applications for minimum safe manning documents or when determining minimum safe manning levels for ships.

Future work

9 These Guidelines are a living document; they should be updated periodically as research reveals new information and new methods are uncovered to deal with the issue of fatigue.

MODULE 1

FATIGUE

Introduction

1 Fatigue is a hazard that affects safety, health and well-being. It presents a considerable risk to safety of life, property, health, security and protection of the marine environment.

2 This module provides a general overview of fatigue and its causes and consequences. This knowledge is important for developing strategies to reduce the risk of fatigue and related incidents.

3 It is recommended that all parties become familiar with module 1 prior to using modules 2 to 6.

Fatigue and life on a ship

4 There is a common misconception that fatigue "comes with the job"; while not particular to the maritime industry, it is certainly pervasive within it. Fatigue is a hazard and needs to be addressed.

5 Fatigue is a problem for all 24-hour-a-day transportation modes and industries, including the maritime industry. However, operational aspects associated with the maritime industry are also more complex than those associated with other industries. For example, variety of ship-types, the pattern and length of sea passage, the number of port visits and port rotations, and the length of time a ship remains in port, all present unique combinations of potential causes of fatigue.

6 The demanding nature of shipping means that:

.1 seafarers may be required to work long and irregular hours;

.2 seafarers may spend an extended period of time working and living away from home, on a ship that is subject to unpredictable environmental factors (i.e. changing weather conditions);

.3 the ship is both a seafarer's workplace and their home while on board; and

.4 while serving on board the vessel, there may not be a clear separation between work and recreation, which can influence their mental and emotional well-being.

7 Technology is sometimes seen as a way to improve the efficiency of work systems. However, technology changes the nature of work and alters workload, therefore it is important to evaluate the impact of technological changes on crew workload and consequently fatigue.

Causes of fatigue

8 Fatigue is caused by a range of factors, but is primarily caused by:

.1 lack of sleep, i.e. inadequate restorative sleep;

.2 poor quality of sleep and rest;

.3 work/sleep at inappropriate times of the body clock (circadian rhythm);

.4 staying awake for long periods;

.5 stress; and

.6 excessive workload (prolonged mental and/or physical exertion).

9 There are many ways to categorize the causes of fatigue. To ensure thoroughness and to provide good coverage of most causes, they have been categorized into five general factors:

.1 seafarer-specific factors;

.2 management factors (ashore and aboard ship);

.3 ship-specific factors;

.4 environmental factors; and

.5 operational factors.

Seafarer-specific factors

10 The seafarer-specific factors are related to lifestyle behaviour, personal habits and individual attributes. Fatigue varies from one person to another and its effects are often dependent on the particular activity being performed.

11 The seafarer-specific factors include the following:

.1 sleep and rest:

.1 quantity, quality and continuity of sleep;

.2 sleep disorders/disturbances; and

.3 recovery rest/breaks;

.2 body clock/Circadian rhythms;

.3 psychological and emotional factors:

.1 fear;

.2 monotony and boredom; and

.3 loneliness;

.4 health and well-being:

.1 diet/nutrition/hydration;

.2 exercise and fitness; and

.3 illness and onset of illness;

.5 stress:

.1 skill, knowledge and training as it relates to the job;

.2 personal issues of concern in personal life; and

.3 interpersonal relationships at work or at home;

.6 medication and substance use:

.1 alcohol;

.2 drugs (prescription and non-prescription);

.3 supplements; and

.4 caffeine and other stimulants;

.7 age;

.8 shift work and work schedules;

.9 workload (mental/physical); and

.10 jet lag.

Management factors (ashore and aboard ship)

12 Management factors relate to how ships are managed and operated. These factors can potentially cause stress and an increased workload, ultimately resulting in fatigue. These factors include:

.1 Organizational factors:

.1 manning policies, levels, and retention;

.2 role of riders and shore personnel;

.3 administrative work/reporting/inspection requirements;

.4 economics;

.5 duty schedule-shift, overtime, breaks;

.6 company procedures, culture and management style;

.7 shore-based support;

.8 rules and regulations;

.9 other resources;

.10 maintenance and repair of the ship; and

.11 drill schedules and training of crew;

.2 Voyage and scheduling factors:

.1 frequency and duration of port calls;

.2 time between ports;

.3 routeing;

.4 weather and sea condition on route;

.5 traffic density on route;

.6 nature of duties/workload while in port and at sea; and

.7 availability of shore leave.

13 Module 2 provides recommended strategies for identifying, mitigating and controlling fatigue risks due to management factors.

Ship-specific factors

14 These factors include some ship features that can affect and contribute to fatigue. Some ship design features affect workload (i.e. automation, equipment design and reliability), some affect the crew's ability to sleep, and others affect the level of physical stress on the crew (i.e. noise, vibration, accommodation spaces, etc.). The following list details some influential ship-specific factors:

.1 ship design;

.2 level and complexity of automation;

.3 level of redundancy;

.4 equipment design and reliability;

.5 inspection and maintenance;

.6 condition of the ship;

.7 physical comfort in work spaces;

.8 location of quarters;

.9 ship motion; and

.10 physical comfort of accommodation spaces.

15 Module 5 provides recommended strategies for identifying, mitigating and controlling fatigue risks due to ship-specific factors.

Environmental factors

16 Environmental factors within areas in which seafarers live and work (both inside and outside the ship) may contribute to the onset of fatigue, and impact both sleep quantity and quality. Environmental factors to consider include noise and vibration, light, ship motion, temperature and humidity, and ventilation/air exchange. Long-term exposure to some of the following may impact a person's health:

.1 **Noise**: (such as main engines, switchboards, TV and conversations) affects the ability to fall asleep, causing sleep loss, or it can alter one's sleep stage or depth of sleep.

.2 **Vibration**: may affect sleep and fatigue. For example, alterations in vibration pattern may keep people awake, keep them from advancing into deeper sleep, or wake them up.

.3 **Light**: (such as colour, intensity and exposure timing) is a complicated environmental factor. In addition, the use of electronic displays that emit blue light (such as computer screens, flat-screen televisions and smartphones) can also influence the body clock and can delay the onset of sleep, especially when used prior to bedtime.

.4 **Ship motion**: depending on the weather and sea conditions, ship motion may interfere with sleep, cause motion-induced fatigue (fatigue caused by the extra energy expended to maintain balance while moving, especially during harsh sea conditions) and seasickness.

.5 **Temperature and humidity**: all excessively hot and cold conditions will make an individual feel less alert and generally more fatigued. It is important that the shipboard temperature and humidity is controllable as this affects sleep and alertness. For example, the body sleeps best when the environment temperature is between 18ºC and 24ºC.

.6 **Ventilation/air exchange**: in addition to controlling temperature and humidity, air quality (e.g. noxious odours or stale air) and design/placement of the ventilation system may interfere with sleep.

Operational factors

17 While seafarers, companies, Administrations and port State authorities are the primary actors, many other stakeholders may also have an impact on shipboard operations and workload. Aspects to consider include inspections, surveys, audits, visits, reporting, security measures and any other additional tasks to be performed on board. Therefore, other stakeholders should contribute to the mitigation of fatigue by considering the impacts of their actions on shipboard operations.

18 Opportunities to mitigate the effects of these factors vary and will be discussed further in subsequent modules.

Important basic concepts in understanding fatigue

19 This section highlights some of the important concepts that provide an overall understanding about fatigue. The most significant aspects of fatigue are:

.1 sleep;

.2 body clock and the circadian rhythm;

.3 time awake;

.4 jet lag;

.5 workload;

.6 stress;

.7 health; and

.8 individual differences.

Sleep

20 Not all sleep has the same quality or provides the same recuperative benefits. In order to satisfy the needs of the human body, sleep must have three characteristics to be most effective:

.1 **Quantity**: it is generally recommended that a person obtain, on average, seven to eight hours of good quality sleep per 24-hour period. To perform adequately and effectively, a person needs the amount of sleep that produces the feeling of being refreshed and alert. Alertness and performance are directly related to sleep. Insufficient sleep will impair alertness. Only sleep can maintain or restore performance levels.

.2 **Quality**: sleep is a highly organized sequence of events that follows a regular pattern of cycles between light and deep sleep. People need deep sleep. Deep sleep is a very restorative phase of sleep.

.3 **Continuity**: sleep quality is dependent upon unbroken cycles of sleep, meaning sleep needs to be uninterrupted in order to retain its restorative value. Six 1-hour naps do not have the same benefit as one 6-hour period of sleep. The more fragmented the sleep cycle, the less restorative sleep becomes. This results in continued feelings of tiredness and often impacts performance and decision-making. If the time of sleep is out of synchronization with a person's body clock, it is difficult to sleep properly. It should be noted that the proportion of time spent in deep sleep decreases as we get older. Sleep also becomes more fragmented as we get older.

21 Many factors contribute to sleep disruption and poor sleep quality; some are within our control while others are not:

.1 environmental factors;

.2 food;

.3 medication and substance use;

.4 psychological factors;

.5 sleep disorders; and

.6 operational factors.

22 Sleep debt is "insufficient accumulated sleep over multiple consecutive 24-hour periods". For example, if an individual needs eight hours of sleep per 24-hour period and only obtains six hours, they have accumulated a sleep debt. Sleep debt will affect an individual's level of alertness and performance. Long-term sleep debt may also lead to health problems. Over time, sleep-deprived individuals may become less aware of just how fatigued they are and become unable to judge their own level of performance.

23 When someone is woken up suddenly, the brain can have difficulty transitioning out of deep sleep. This is known as sleep inertia. Sleep inertia causes feelings of grogginess and disorientation, with impaired short-term memory and decision-making, and can last longer than 30 minutes. Sleep inertia can also occur following lighter sleep, but it tends to be longer and more disorienting when someone is woken abruptly out of deeper sleep.

Body clock and the circadian rhythm

24 The time of day in which work takes place is a key risk factor in determining fatigue. This is because, independent of prior sleep and wakefulness, humans are biologically programmed to be active during the day and to sleep at night.

25 Each individual has a body clock, and this clock regulates the body's circadian rhythm. Our bodies move through various physical processes and states within a 24-hour period, such as sleeping/waking, and cyclical changes in body temperature, hormone levels, sensitivity to drugs, etc. This cycle represents the circadian rhythm. The body clock is synchronized to the traditional pattern of daytime wakefulness and night-time sleep.

26 The body clock makes a person sleepy or alert on a regular schedule whether they are working or not. In normal conditions, the sleep/wake cycle follows a 24-hour rhythm; however, the cycle is not the same for everyone.

27 Independent of other factors, fatigue is most likely, and when present, most severe, in the early hours of the morning, coinciding with the strongest drive for sleep. This period typically occurs between the hours of 3 and 5 a.m. and is commonly referred to as the window of circadian low (WOCL).

28 In general, seafarers working through the night may be at a higher risk of fatigue and have to make additional effort to maintain alertness and performance. This is supported by maritime studies and investigations in which fatigue was found to be a contributing cause in incidents that mainly occurred between midnight and 6 a.m. This indicates that from a maritime perspective high risk times may fall between these hours.

29 Apart from the WOCL, another distinct dip occurs between 3 and 5 p.m. (best known as the post-lunch dip).

30 The states of sleep/wakefulness and circadian rhythms interact in several ways:

.1 The two can work against each other and thereby weaken or negate each other's effect. For example, a well-rested person is still affected by a circadian low point; conversely, a person who is sleep-deprived may feel a momentary increase in alertness due to a peak in circadian rhythm.

.2 The two can also work in the same direction, thereby intensifying the effect they each have on a person's level of alertness. For example, when someone is sleep-deprived, a circadian low point will further exacerbate the feeling of sleepiness.

31 For many seafarers, working patterns conflict with their body clock. Irregular schedules caused by shifting rotations, crossing time zones, etc. cause the circadian rhythms to be out of synchronization. As circadian adjustment to a particular pattern of work and rest is a relatively slow process (only adjust by an hour or two each day), constant changes impair sleep. Work that requires seafarers to be awake and working at night or early morning or to work for extended periods can cause disruptions to the body clock resulting in increased fatigue.

32 Even though the body clock can be reset over time, such as when changing times zones for an extended period, research shows that it cannot be permanently adjusted to a reversed cycle of work and sleep. Because the body clock may not adapt fully to altered sleep/wake patterns:

.1 seafarers who work through the night can be expected to be sleepy and have to make additional effort to maintain alertness and performance; and

.2 some seafarers may be fatigued at the start of their work period, as they adapt to their sleep routine.

Time awake

33 How long an individual is awake affects sleepiness and consequently fatigue levels. The longer an individual has been awake, the poorer their performance. In general, the longer a seafarer remains awake, the stronger the drive for sleep, and the higher the levels of fatigue. During the first hours awake, the urge to sleep may go unnoticed, but as the amount of continuous wakefulness approaches 16 hours, awareness of the pressure to sleep is highly likely. This occurs sooner if the seafarer is already suffering from sleep debt.

34 Alertness and performance levels begin to decrease after a number of hours awake, with long duty periods associated with higher levels of fatigue than shorter duty periods due to extended wakefulness and demands on attention. In addition, the longer an individual has continuously been on a task without a break, the more likely they will be fatigued. Accident rates rise exponentially after 12 hours of consecutive work, particularly when working at night.

35 Long work hours are associated with poor performance, higher injury rates, and poorer safety and/or health outcomes (both mental and physical). Another important aspect to consider are work commutes. Many seafarers may be required to travel or drive long distances to the ship and then have to work.

Jet lag

36 Jet lag occurs following long flights through several time zones. Seafarers crossing time zones to join their ship are exposed to a sudden change in the day/night cycle causing circadian disruption. It is a condition that causes fatigue in addition to sleep deprivation and irritability. The body clock will eventually adapt to a new time zone; however, depending on the new schedule, it takes several days to adjust. During the period of adaptation to the new time zone, common symptoms include wanting to eat and sleep at times that are out of step with the local routine, problems with digestion, degraded performance on mental and physical tasks, and mood changes. It is easier to adjust while crossing from east to west than from west to east.

Workload

37 Workload refers to the type and intensity of tasks performed. Fatigue can occur when workload is either very high or very low. High and low workload may be present in a shipboard work environment, and are likely to induce fatigue. Fatigue resulting from workload becomes an increasing concern when combined with long periods of wakefulness and long duty hours.

.1 **High workload**: both high physical workload and high mental workload (such as tasks with excessive demands on attention) may lead to fatigue. Examples of high workload routinely experienced on board ships include, but are not limited to, navigating in congested and dangerous waters; frequent port calls; navigating in conditions of poor visibility and/or bad weather; entering and exiting a port/harbour; having to complete multiple tasks; and tank cleaning and cargo operations.

.2 **Low workload**: monotonous tasks, such as monitoring (of engine-room displays for example) can result in loss of interest and boredom, which also increases the effects of fatigue. This can be a particular problem when conducting bridge or engine monitoring and vigilance tasks across long periods of time. This can be readily seen when a person is required to maintain a period of concentrated and sustained attention, especially during the night (night duty, for example). People are generally not good at long duration vigilance tasks. Performance and alertness is further impacted if vigilance and monitoring tasks need to be carried out during the night-time hours, specifically between midnight and 5 a.m.

Stress

38 Stress occurs when a person is confronted with an environment or situation that poses a threat or demand, and the individual becomes aware of his or her inability to cope or difficulty in coping with the environment (a feeling of being overwhelmed). This can result in reduced work performance and health problems. Stress is influenced by many characteristics of the work environment or issues with or changes to personal, family, or home environment. Stress can be caused by a number of factors, including:

.1 environmental factors (e.g. constant or irregular noise, vibration, temperatures, weather, ice conditions);

.2 personal circumstances (e.g. family problems, home sickness, isolation);

.3 inadequate restorative sleep;

.4 broken or interrupted sleep or rest periods;

.5 excessive working hours;

.6 intense mental and/or physical workload; and

.7 onboard interpersonal relationships.

39 These stressors, and others, can impact the extent to which a seafarer is able to acquire sufficient sleep and consequently lead to fatigue. For example, family aspects that require attention but are beyond the seafarer's control may lead to short sleep duration and extended wakefulness. Seafarers may be away from home for extended periods of time. Loneliness, isolation, family conflict and concern about family members may provide enough stress to be considered risk factors.

Health

40 Healthy lifestyle choices such as good physical fitness and a healthy diet have been reported to reduce fatigue and improve alertness and performance. Conversely, unhealthy lifestyle choices can negatively impact sleep and therefore contribute to fatigue.

.1 **Nutrition**: a poor diet that does not include fresh fruit and vegetables can contribute to fatigue by adversely affecting a seafarer's health. In addition, irregular meal times can adversely affect digestion, which also follows the circadian rhythm. Digestion is programmed to be most efficient during the day and much less so at night. Food eaten at night is digested at a slower rate. This can often lead to feeling bloated or constipated and can cause heartburn and indigestion. Gastrointestinal upsets are very common in people who eat outside of traditional meal times. These upsets can be made worse by drinking tea, coffee or alcohol. Additionally, when lying down right after eating a large meal, acid reflux may occur. Night workers are 5 times more likely to get peptic ulcers than day workers.

.2 **Hydration**: dehydration is also a factor that contributes to fatigue. When the body is low on water, it tries to conserve what it has left. It does this by reducing activity and making the body relax and slow down. When relaxed, people have a higher chance of falling asleep. Being dehydrated can also make people feel light-headed and cause headaches. In addition to maintaining cognitive function and alertness, drinking adequate water helps keep the digestive and circulatory systems operating properly. Water brings healthy nutrients to cells and carries away toxins.

.3 **Exercise and fitness**: poor physical fitness adversely affects overall health and causes people to tire easily. Exercise speeds up metabolism and increases blood flow, which helps to keep a person awake. Exercise also helps the body cope with stress and can help individuals suffering from depression, a condition that can be characterized by fatigue. Physical exercise can also help reduce a person's susceptibility to certain diseases and infections. The inability to exercise is considered a risk factor because it is a circumstance that takes away a crew member's ability to increase physical fitness, enhance sleep, think clearly and manage stress.

.4 **Caffeine and other stimulants**: caffeine can be found in beverages such as coffee, tea and some soft drinks. Caffeine can improve alertness and concentration in moderate doses, but it is not a substitute for adequate sleep and rest. Too much caffeine can have harmful effects such as increased

heart rate and blood pressure, and can cause fatigue in some people. It takes caffeine about 15 to 30 minutes to enter the body's system, and its physiological effects peak about an hour after the drug reaches the bloodstream. The effects of caffeine can vary highly from individual to individual and depend on physical condition, age, level of sleep debt, frequency of use and time of day. Generally, caffeine levels drop by half every five or six hours. Its effects can last long after consumption and may interfere with needed sleep. Caffeine shortens total sleep time by preventing sleep. Caffeine consumption can also cause dehydration.

.5 **Alcohol**: although alcohol is a central nervous system depressant, it can impair the quality of sleep. Alcohol can lead to increased sleepiness and reduced alertness, even after the alcohol is no longer detectable. There are also serious health consequences related to the long-term abuse of alcohol. Many shipping companies have "zero alcohol tolerance."

.6 **Nicotine**: nicotine is highly addictive and the dangers to health are well documented. Nicotine users generally have more disturbed sleep, typically taking longer to fall asleep and experiencing more wake time during a sleep period.

.7 **Drugs**: it is important for seafarers to be aware of how drugs and supplements may affect their health and their sleep-wake cycles. Drug effects vary not only from person to person, they can also vary for the same person depending on time of day, mood, tiredness and the amount of food eaten. In addition, there are other drugs prescribed for specific ailments that can have sedating side effects. Some prescription drugs can affect people's ability to operate machinery (induce sleepiness). They may also interact with existing fatigue levels and other drugs (including alcohol) and supplements, further affecting performance. Some over-the-counter drugs used for pain relief or colds and flu may increase drowsiness and fatigue-related symptoms.

.8 **Supplements**: there are now a number of nutritional supplements, natural products and energy drinks that are available on the market that directly influence sleep/wake states. Just because they are sold over the counter does not mean they are safe or appropriate for everyone. These products may interact with prescription or over-the-counter drugs to further affect performance. Individuals should proactively seek advice and guidance from their healthcare providers before using these products to learn about their appropriate use.

.9 **Sleep disorders**: other health-related aspects are the wide variety of sleep disorders, which are known to disrupt the quality of sleep and make restorative sleep impossible, even when individuals spend enough time trying to sleep. The most common sleep disorders are obstructive sleep apnoea, insomnia, restless legs syndrome, shift work sleep disorder and narcolepsy. Undiagnosed or untreated sleep disorders can cause sleepiness problems. Sleep disorders pose a particular risk for seafarers, especially as maritime operations already expose seafarers to restricted sleep. Large numbers of individuals suffering from sleep disorders are unaware of and have not been diagnosed or treated for their disorder.

.1 Obstructive sleep apnoea (OSA) results in breathing being interrupted during sleep. Repetitive episodes of non-effective breathing, very shallow breaths or inadequate breaths lead to frequent partial arousals from sleep, resulting in ineffective sleep and sleep debt. OSA is a potentially serious sleep disorder resulting in excessive daytime sleepiness and can lead to cardiovascular problems. Sleep apnoea, which may be indicated by loud snoring with pauses of silence, often goes undiagnosed and untreated and has been known to be a contributing factor to incidents in all modes of transportation. Some risk factors include excessive weight, high body mass index (BMI), high blood pressure, smoking and diabetes.

.2 Insomnia is the most prevalent sleep disorder and is characterized by an inability to fall asleep and/or by waking up during the night and having difficulty going back to sleep. Long-term insomnia is more common in women than men and tends to increase with age. Short-term insomnia may be caused by emotional or physical discomfort, stress, environmental noise, extreme temperatures or jet lag, or may be the side effect of medication. Secondary insomnia may result from a combination of physical or mental disorders, undiagnosed or uncontrolled sleep disorders and effects of prescription or non-prescription medications.

.3 Restless legs syndrome (RLS) is a movement disorder that is often associated with a sleep complaint. People with RLS have unpleasant leg sensations and an almost irresistible urge to move their legs. Symptoms are worse during inactivity and often interfere with sleep. Sitting still for long periods becomes difficult; symptoms are usually worse in the evening and night and less severe in the morning.

.4 Shift work sleep disorder is characterized by insomnia and excessive sleepiness affecting people whose work hours overlap with the typical sleep period. There are numerous shift work schedules (permanent, intermittent or rotating); consequently, the manifestations of this disorder are quite variable. Those with shift work disorder complain more of mood problems such as impatience and depression, as well as more self-reported health complaints such as ulcers and substance use.

.5 Narcolepsy is a chronic sleep disorder that usually becomes evident during adolescence or young adulthood. The main characteristic of narcolepsy is excessive and overwhelming daytime sleepiness (even after adequate night-time sleep). A person with narcolepsy is likely to become drowsy or to fall asleep at inappropriate times and places, and in extreme cases during periods of activity. Daytime sleep attacks may occur without warning and may be irresistible. In addition, night-time sleep may also be fragmented.

Individual differences

41 Individuals respond to fatigue differently and may become fatigued at different times, and to different degrees of severity, under the same circumstances. There are also individual characteristics related to circadian rhythms. People can be characterized as morning or evening types depending on the period of the day when they perform at their best.

Effects of fatigue

42 When a person is affected by fatigue, performance on the job can be significantly impaired. Impairment will occur in every aspect of human performance (physically, emotionally, and mentally) such as in decision-making, response time, judgement, hand-eye coordination and countless other skills. When impairment due to fatigue, such as impaired memory or poor communication, coincides with other risks in the environment, incidents can result. This is evidenced in a number of maritime casualties in which fatigue was a contributory factor. Maritime studies have also confirmed the association between fatigue and poor performance.

43 People are poor judges of their own level of fatigue, performance and decision-making. The following is a sample of fatigue's known effect on performance:

.1 Fatigued individuals become more susceptible to errors of attention and memory (for example, it is not uncommon for fatigued individuals to omit steps in a sequence).

.2 Fatigued individuals will often select strategies that have a high degree of risk on the basis that they require less effort to execute.

.3 Fatigue can negatively affect an individual's ability to identify and respond to stimuli.

.4 Fatigue can also negatively affect problem-solving, which is an integral part of handling new or challenging tasks.

44 Particularly dangerous situations at sea arising from sleep debt are brief, uncontrolled and spontaneous sleep episodes while working, termed microsleeps. During a microsleep, the brain disengages from the environment (it stops processing visual information and sounds). Sleep deprivation, which is caused by cumulative sleep debt, can make people more susceptible to microsleeps. The likelihood of microsleeps is even greater if the individual is on duty during a circadian low.

45 The range of effects and signs of fatigue can typically be grouped into three categories: cognitive (e.g. loss of vigilance), physical (e.g. yawning, micro-sleeps) and behavioural (e.g. irritability, mood). The table below outlines some of the major symptoms under each category; however, it is not inclusive. Additionally, many of these symptoms may be subtle.

Table 1: Effects of fatigue

COGNITIVE	
PERFORMANCE IMPAIRMENT	SIGNS/SYMPTOMS
Inability to concentrate	• Unable to organize a series of activities • Preoccupied with a single task • Focuses on a trivial problem, neglecting more important ones • Reverts to old but ineffective habits • Less vigilant than usual • Decline in ability to solve complex problems • Lapses of attention • Difficulty in multitasking
Diminished decision-making ability	• Misjudges distance, speed, time, etc. • Fails to appreciate the gravity of the situation • Overlooks items that should be included • Chooses risky options • Greater indecisiveness
Poor memory	• Fails to remember the sequence of task or task elements • Difficulty remembering events or procedures • Forgets to complete a task or part of a task • Memory lapses
Slowing of cognitive processes	• Responds slowly (if at all) to normal, abnormal or emergency situations
PHYSICAL	
PERFORMANCE IMPAIRMENT	SIGNS/SYMPTOMS
Involuntary need to sleep	• Slow eyelid closures • Droopy eyelids • Itchy eye • Nodding off • Inability to stay awake
Loss of control of bodily movements	• Affected speech, e.g. it may be slurred, slowed or garbled, or hard to find the right words • Feeling heaviness in the arms and legs • Clumsiness, such as increased frequency of dropping objects like tools or parts • Difficulty with hand-eye coordination skills (such as switch selection) • Tremors

Health Issues	• Headaches • Giddiness • Rapid breathing • Digestion problems • Leg pains or cramps • Insomnia • Sudden sweating fits • Heart palpitations / irregular heart beats • Loss of appetite (and sometimes an increase in unhealthy eating habits)
BEHAVIOURAL	
PERFORMANCE IMPAIRMENT	SIGNS/SYMPTOMS
Mood change	• Quieter, less talkative than usual • Unusually irritable • Decreased tolerance and anti-social behaviour • Depression
Attitude change	• Fails to anticipate danger • Fails to observe and obey warning signs • Seems unaware of own poor performance • More willing to take risks • Ignores normal checks and procedures • Displays a "don't care" attitude • Less desire to socialize • Increasing omissions and carelessness • Low motivation

46 Sleep debt, over long periods of time (more than two weeks), has long-term effects on health and clinical illnesses, increasing the risks of pain, stress, obesity, coronary heart disease, gastrointestinal disorders and diabetes. Long-term effects also point to mental health problems such as negative mood states and depression.

47 Fatigue is known to affect performance and reduce individual and crew effectiveness and efficiency, decrease productivity, lower standards of work, and may lead to errors. The instances of injuries and incidents reportedly related to fatigue within maritime operations have resulted in great economic, environmental and human cost. Thus, addressing the risks of fatigue and its causes is essential.

ILO and IMO instruments related to fatigue

48 The following IMO instruments contain guidance on fatigue-related aspects:

.1 **International Convention on Standards of Training Certification and Watchkeeping for Seafarers (STCW), 1978, as amended**

.1 Regulation VIII/1 (Fitness for duty) states that "each Administration shall, for the purpose of preventing fatigue:

.1 establish and enforce rest periods for watchkeeping personnel and those whose duties involve designated safety, security and prevention of pollution duties in accordance with the provisions of section A-VIII/1 of the STCW Code; and

.2 require that watch systems are so arranged that the efficiency of all watchkeeping personnel is not impaired by fatigue and that duties are so organized that the first watch at the commencement of a voyage and subsequent relieving watches are sufficiently rested and otherwise fit for duty."

.2 Regulation VIII/2 (Watchkeeping arrangements and principles to be observed) states that "Administrations shall direct the attention of companies, masters, chief engineer officers and all watchkeeping personnel to the requirements, principles and guidance set out in the STCW Code which shall be observed to ensure that a safe continuous watch or watches appropriate to the prevailing circumstances and conditions are maintained on all seagoing ships at all times."

.3 In addition, part A of the STCW Code sets minimum periods and frequencies of rest and requires that watch schedules be posted where they are easily accessible.

.2 **International Safety Management (ISM) Code**: This Code introduces safety management requirements on ship companies to assess all identified risks (both ashore and afloat) that affect safety (to ship and personnel) and environment and establish appropriate safeguards. The fatigue-related requirements include the requirement for the company to:

.1 develop, implement and maintain a safety management system (section 1.4);

.2 ensure that each ship is manned with qualified, certificated and medically fit seafarers in accordance with national and international requirements and is appropriately manned in order to encompass all aspects of maintaining safe operations on board (paragraph 6.2);

.3 ensure necessary shipboard support is provided so that the master's duties can be safely performed (paragraph 6.1.3); and

.4 provide familiarization and training for shipboard personnel (paragraphs 6.3, 6.4 and 6.5).

.3 ***Principles of minimum safe manning*** **(resolution A.1047(27))**: This resolution provides guidelines for determining minimum safe manning. In particular in ensuring "fitness for duty", paragraph 1.4.2 of annex 2 states that "in determining the minimum safe manning of a ship, consideration should also be given to the capability of the master and the ship's complement to coordinate the activities necessary for the safe operation and for the security of the ship and for the protection of the marine environment."

.4 ***Fatigue factors in manning and safety*** **(resolution A.772(18))**: This resolution provides a general description of fatigue and identifies the factors of ship operations which may contribute to fatigue.

49 The following ILO instrument contains guidance on fatigue-related aspects:

.1 **Maritime Labour Convention (MLC), 2006**. Relevant aspects of the MLC include, but are not limited to:

.1 **Regulation 2.3**: To ensure that seafarers have regulated hours of work or hours of rest.

.2 **Regulation 2.4**: To ensure that seafarers have adequate leave.

.3 **Regulation 2.7**: To ensure that seafarers work on board ships with sufficient personnel for the safe, efficient and secure operation of the ship.

.4 **Regulation 3.1**: To ensure that seafarers have decent accommodation and recreational facilities on board.

.5 **Regulation 3.2**: To ensure that seafarers have access to good quality food and drinking water provided under regulated hygienic conditions.

.6 **Regulation 4.3**: To ensure that seafarers' work environment on board ships promotes occupational safety and health.

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MODULE 2

FATIGUE AND THE COMPANY

1 Module 2 contains guidance for the company in assessing, mitigating and managing the risk of fatigue in operational environments.

Is fatigue an important issue in shipboard operations?

2 Fatigue has been recognized as an important occupational health and safety issue for seafarers. Fatigue has the potential to greatly increase the risk of incidents and injuries in the work place. It disrupts circadian rhythms and results in digestive problems, confusion, lethargy, respiratory problems, depression and irritability. Fatigue adversely affects seafarer performance. It diminishes attentiveness and concentration, slows physical and mental reflexes and impairs rational decision-making capability.

3 Research has established a clear link between fatigue and accidents at sea. Clearly, addressing the issue of fatigue should have a positive effect on personnel safety and has the potential to cut costs for the company by reducing injury and physical damage to high-value assets and the environment.

4 Fatigue poses a risk to any position on board, but especially those that have critical safety and security responsibilities. Should an individual fail to carry out an allotted task due to fatigue, the crew runs the risk of a safety or security incident. Any risk management strategy must focus on mitigating the potential for such hazards to arise by addressing the causes of fatigue. Systems and work procedures should be critically examined to engineer out design deficiencies that could contribute to fatigue. The company should provide an adequate level of support for managing the risks of fatigue at both the organizational and operational levels.

What elements of fatigue can the company influence?

5 While it is not possible for the company to regulate and oversee the sleeping habits of every seafarer on every ship, it is within its capability to mitigate the risks of fatigue through ship design, operational and manning policies. The *Principles of minimum safe manning* (resolution A.1047(27)) provides for an assessment of the tasks, duties and responsibilities of the ship's complement to ensure that manning levels are adequate at all times to meet all conditions and requirements including meeting peak workload situations and emergency conditions. Hours of rest are presently controlled by a prescriptive formula set out in chapter VIII of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) 1978, as amended. Managers should be aware (when applying these hours of rest) that considering the effects of circadian rhythm and sleep debt is important for ensuring that rest periods are of high quality. It also cannot be too highly stressed that rest means rest, not substituting a different form of work. This should be supported by appropriate manning, resources, processes and policies, so that fatigue risks can be managed in a way that supports safe, compliant and productive operations. Importantly, fatigue risk control measures forming part of the company support should:

.1 identify and assess fatigue risks;

.2 assess operational workload requirements in accordance with the *Principles of minimum safe manning* (resolution A.1047(27));

.3 ensure that manning and resources are adequate and available for assessed workload requirements and to conduct all ship operations safely;

.4 ensure company-wide awareness of the risk of fatigue; and

.5 ensure a healthy shipboard environment.

6 Figure 1 below provides a framework to assess the hazards associated with fatigue and different strategies to mitigate the risk of fatigue.



Hazard Assessment	Risk Mitigation
A. Is company providing effective **support** for managing the risks of fatigue?	Fatigue Training Awareness Adequate Resources Healthy shipboard environment
B. Are seafarers provided with adequate **sleep opportunity**? (Quantity and Quality)	Hours of work and rest requirements Duty Scheduling and Planning Workload Management Work and Living Environment
C. Is the sleep obtained by seafarers adequate? (Quantity and Quality)	Company and seafarer responsibility
D. Are seafarers able to **maintain adequate alertness** and performance while on duty?	Self and Peer Fatigue Monitoring Ensuring 'Fit for Duty'
E. Are fatigue related events (near miss and accidents) **reported and analysed**?	Fatigue Reporting and Analysis

Figure 1: Framework to mitigate the risk of fatigue

7 Companies' records of hours of work and rest are generally assessed against regulatory requirements. Planning tools are available that take into account the circadian rhythm. The use of such planning tools may assist companies in doing the following:

.1 Analyse planned work routines to ascertain the risk of fatigue.

.2 Monitor work hours on board the ship to determine whether or not the risk of fatigue is increasing as a result of the work arrangements or from any variations that may have occurred.

.3 Analyse and compare information related to hours of work to determine the effectiveness of employed routines, compared to other alternatives.

8 It is important that companies adopt a fatigue mitigation and control strategy that is tailored to the individual operational requirements.

How can the company ensure that fatigue prevention is practised on board?

9 The company should consider the following:

.1 ISM Code requirements for clear, concise guidance on operational procedures on board;

.2 ensure adequate resources, including manning levels;

.3 promote a safety reporting culture with open communication and no fear of reprisal;

.4 the need for joining seafarers to be adequately rested before assuming duties;

.5 schedule time for proper handover on crew change;

.6 voyage length, time in port, length of service and leave ratios;

.7 multicultural issues; language barriers, social, cultural and religious isolation;

.8 interpersonal relationships, stress, loneliness, boredom, social deprivation and increased workload as a result of small crew numbers;

.9 provision for shore leave and onboard recreation, family communication;

.10 watchkeeping arrangements;

.11 job rotation, if practicable;

.12 adequate sleeping berths and accommodation;

.13 adequate quality and quantity of food for proper nutrition;

.14 read other modules of these guidelines for additional potential managerial mitigation tools; and

.15 modification of present ship design or future designs, if necessary.

10 Fatigue training and awareness are essential components. The company should ensure all personnel have appropriate training. This includes shore-based personnel whose decisions may impact on the management of fatigue (such as those involved in resource planning, including ship manning levels, and duty scheduling decisions) and fatigue-related processes. This is important, as their decisions potentially affect fatigue levels of seafarers and consequently shipboard safety.

11 Initial fatigue-related training should establish a common level of understanding among seafarers and shore-based personnel about the dynamics of sleep loss and recovery, the effects of the body clock on circadian rhythms, the influence of workload, and the ways in which these factors interact with operational demands to produce fatigue (covered in module 1). In addition, it is useful for all seafarers to have information on how to manage their personal fatigue and sleep issues (covered in module 3).

12 This process, as with any other training, should be ongoing in nature. Hence, training should be conducted on an initial and recurrent basis. The interval between training should be determined by the company, given their operational characteristics and training needs analysis.

13 Promoting a safety reporting culture is necessary. The company should ensure that processes are in place to provide seafarers with the opportunity to report situations when the seafarer has been unable to obtain adequate sleep or feels at risk of making fatigue-related errors, specifically if conducting safety critical tasks. This process should allow for open communication and reporting between seafarers, their supervisors and the company, and should prohibit any action directed against a seafarer for such communications or reports.

Adequate resources (including ship manning levels)

14 Adequate resources, including manning, is one of the primary determinants of seafarers' duty hours, workload, duty scheduling, average time off duty, and other key factors that can have an influence or elevate fatigue. The company should ensure that adequate resources are available with a need to proportionally balance varying work and task demands and deal with unexpected surge to reduce the risk of fatigue across shipboard operations.

15 Manning levels should match the operational workload on board the ships and this workload should be managed efficiently. Operational workload is determined through an assessment by the company.

16 Although the master is responsible for managing the ship and its crew, the company should ensure that the master is adequately supported and resourced to conduct shipboard duties and operations safely and effectively.

17 Effective operational planning is critical to ensuring adequate resources, including manning, are available at all times so that operational and other demands placed on the ship and its crew can be managed safely and effectively. Planning should account for:

.1 varying work and task demands within and across days, e.g. amount of time the ship is travelling through confined and congested waters and less confined open waters;

.2 trading patterns, i.e. number of port calls – the more port calls the higher the workload;

.3 planning for disturbances, such as weather, ship movement in port, port entry and exit delays and port surveys and inspections;

.4 ensuring adequate manning is available to cover planned and unplanned aspects such as training, illnesses, injuries and sickness; and

.5 ensuring company commercial obligations or interests do not impinge on or affect safety in any way.

18 The company should consider strategies to deal with periods of high workload and to manage this accordingly. Appropriate strategies may include the following:

.1 The allocation of crew numbers to peak times and demands is a fundamental factor in minimizing the exposure to risks associated with extended duty hours. Numbers and types of seafarers should be scheduled based on predictable operational demands to account for daily, weekly and monthly operational trends.

.2 Ensure the master is well resourced and supported to carry out all shipboard tasks safely and to allow for unexpected surge and overriding operational conditions.

.3 Ensure there are adequate resources, including manning, available to complete shipboard tasks safely without placing excessive demands on seafarers.

.4 Augment with shore-based support or additional rest when the ship is in port, such as during loading and unloading and port inspections, to ensure shipboard crew obtain adequate time off for rest and sleep and are fit for duty when the ship leaves port.

.5 Provide shipboard administrative support or a means for relieving the burden associated with paperwork and related administrative tasks.

.6 Where practicable, provide remote support to shipboard crew in areas such as paperwork, loading/unloading calculations.

.7 Utilize other crewing concepts, such as the use of port captains and/or shore-based crew.

.8 Plan arrival and departures (tides in ports, delays due to weather, pilotage boarding, etc.) to take into account adequate sleep and rest.

19 An important aspect that needs to be mentioned is that of "overriding operational conditions". In accordance with section B-VIII/1 of the STCW Code "overriding operational conditions" should be construed to mean only essential shipboard work which cannot be delayed for safety, security or environmental reasons or which could not reasonably have been anticipated at the commencement of the voyage. This means that they should not be occurring on a regular basis. Planning, using risk assessment tools and operational experience, can foresee these potential disruptions or delays, e.g. weather, port inspections, traffic congestion during departure/arrivals and illness of seafarers.

Healthy shipboard environment

20 Seafarers are required not only to work but also to live on board a ship. Hence, ensuring a healthy shipboard environment is crucial to minimizing the risks of fatigue. The most important aspects should include:

.1 Healthy eating: healthy nutritious food is available and served on board and crew afforded unlimited access to drinking water.

.2 Healthy sleep: the shipboard sleeping environment should provide for comfortable and good quality sleep (bedding, pillows, mattresses, adequate light management, etc.).

.3 Exercise: adequate exercise facilities are provided (such as well-designed and equipped training facilities and outside spaces), to ensure seafarers can maintain a healthy lifestyle on board.

.4 Stress: adequate shipboard measures are in place to recognize and ensure adequate support to seafarers suffering from stress.

21 Furthermore, initial ship design plays a part in ensuring a healthy operational environment (see module 5).

Adequate sleep opportunity

22 Effective fatigue management is predominantly about ensuring that seafarers are provided with adequate sleep opportunity.

23 It is not correct to assume that a given rest period from duty will provide a given level of sleep and hence recovery. The length of the rest period is only one key factor. The relationship between the recovery value of off-duty periods and the actual amount of sleep obtained in a shipboard environment is increasingly complex. As highlighted in module 1, sleep quantity and quality (and its restorative value) depends on going through uninterrupted sleep. The more sleep is fragmented by waking up, the less restorative value sleep has in terms of how seafarers feel and function when they are on duty.

24 Shipboard-related factors that affect sleep include the design of duty schedules, i.e. length and timing of duty periods, length and timing of breaks within and between a duty period, and the environment, e.g. heat, humidity, noise, vibration, lighting levels, ship routines, diet. These can all have negative effects on the amount of time seafarers are allocated for sleep in a 24-hour period.

Duty scheduling and planning

25 Duty scheduling and planning is a key factor in managing fatigue. Hence, the company should be responsible for ensuring duty schedules provide adequate opportunity for sleep.

26 Companies must, at the very least, be in compliance with STCW regulation VIII/1.

27 From a practical perspective, it is important to determine whether a given duty schedule, on average, enables adequate sleep opportunity. There are seven primary duty schedule considerations that should be taken into account when scheduling. They are:

.1 **Work hours (work periods)**: as indicated in module 1, as the length of a given period of work increases, the subsequent sleep opportunity decreases. Research has demonstrated that, apart from a reduction in performance, extended hours of work are also associated with reduced individual well-being, reduced organizational commitment and poor health outcomes. Administrative work, shipboard drills, training, ship loading and unloading tasks are all tasks that may affect seafarers' opportunities to gain adequate sleep. These factors in turn have been linked to declining levels of productivity and safety.

.2 **Rest hours (rest periods) between work periods**: this is the length of time off between work periods and should reflect the fact that seafarers do not simply fall asleep as soon as they are off duty and wake just before they go back on duty. Seafarers, like shore-based workers, have many activities and responsibilities to manage between work periods such as eating, showering, socializing with other crew, relaxing, studying and writing to and communicating with family members and friends back home. Fatigue increases as the number of rest hours decrease; therefore rest hours should provide for adequate sleep opportunity, time to complete those other tasks noted above, be adaptable to the individual circadian rhythm and account for

the effects of sleep inertia after waking. Hence, the interval between two successive work periods should allow sufficient time to obtain adequate sleep before the start of the next work period.

.3 **Night watches or work**: as indicated in module 1, seafarers working during night-time, specifically during the circadian low, can experience severe performance degradation initially. If the seafarer maintains a regular schedule they may adapt over time. However, it is important to provide those seafarers working during night-time with a good sleeping opportunity and environment during the day.

.4 **Short rest breaks within work periods**: short rest breaks benefit performance and help maintain alertness. As indicated in module 1, one of the most important determinants of fatigue is "time on task". Frequent short breaks are associated with performance benefits and result in better fatigue management when the timing of rest is at the discretion of the individual. While it is recognized that this may not always be feasible in a shipboard environment, it should be noted that the "time on task" effect can also be reduced during the work period by task rotations/substitutions.

.5 **Naps**: naps are an effective countermeasure to fatigue, exhaustion from long work hours and restricted sleep. Whether before an anticipated short night's sleep or after, brief naps improve performance and alertness, and delay fatigue-induced performance degradation. Overall, research has shown that the benefits of controlled napping outweigh the potential risks associated with sleep inertia.

.6 **Recovery sleep**: the provision for sufficient recovery time following periods of sleep debt is important. It should be noted that provision of minimum rest periods may not sufficiently acknowledge the critical role that the circadian rhythm plays in the rate at which fatigue accumulates and the rate at which people recover. To work safely across a given duty and to then return to the next work period sufficiently recovered requires that the seafarer obtains sufficient quantity and quality of sleep between work periods. Sleep opportunities during the circadian low are preferable because sleep that occurs during the circadian low provides the most recuperative value.

.7 **Reset breaks**: as the risk of fatigue increases over successive work days of sleep debt, it seems logical that some "recovery" must take place over spans of rest days. This is typically an issue at sea as seafarers are exposed to potentially arduous duty schedules over a long period of time (in excess of seven days, sometimes months on end) without the possibility of a reset break. It is recognized that in a shipboard environment this is likely not practical; however, this may be a factor to consider when determining crew rotation.

28 Companies should consider napping and short break policies to manage fatigue if practicable.

29 Companies should also acknowledge impairment through sleep inertia when planning tasks and activities, giving adequate time for seafarers to be alert before performing critical tasks, when possible.

Tools to assess fatigue in scheduling

30 The planning of duty schedules based on fatigue science as well as operational requirements permits predictive identification of fatigue hazards. This assists in allocating adequate rest periods that provide sufficient sleep opportunity.

31 There are useful additional tools for the mitigation and control of fatigue such as:

.1 fatigue risk assessment tools: the risk level of a specific duty schedule may be assessed via a fatigue risk score; and

.2 fatigue predictive software tools: models and related software to predict fatigue levels for specific operations can be useful additional tools for the management of fatigue risks, as mentioned in paragraph 7.

32 Such tools should not be used in isolation nor be the main driver for duty scheduling decisions, as they are not sufficient to determine the full extent of fatigue-related risk. They should always be supported by other operational data. Their main purpose should be limited to identifying potentially fatigue-inducing duty schedules or scheduling hot spots and allow for better decisions in the selection of duty schedules. This is because numerous unforeseen circumstances can cause changes to planned schedules, e.g. weather conditions, unexpected technical problems or seafarers' illnesses. Seafarer fatigue is the result of what is actually worked, not what is planned. Thus another proactive approach for identifying fatigue hazards is to analyse actual duty schedules in operation.

Workload management

33 As discussed in module 1, mental and physical demands of work can contribute to a seafarer becoming impaired by fatigue in a number of ways. Concentrating for extended periods of time, performing repetitious or monotonous work, and performing work that requires continued physical effort can increase the risk of fatigue. Mental fatigue and physical fatigue are different and a seafarer can experience them at the same time. It is important to be aware of a seafarer's optimal level of workload and stress, and to have realistic attitudes towards these. Understanding that different people react differently to stressful situations (such as emergencies, family problems at home, job-related) is critical for effective interventions. Hence, the use of effective communication with seafarers and monitoring and observing any behaviours that may indicate a change to a seafarer's fatigue as a result of workload is important (see fatigue signs and symptoms in module 1) .

34 Typical techniques for managing workload while on duty include prioritization of tasks, task delegation, task rotation, crew rotation and task shedding. A list of risk mitigation strategies that should be used in managing workload may include:

.1 Carefully considering task design according to the workload and the available resources, including manning.

.2 Reducing the amount of time seafarers need to spend performing sustained physically and mentally demanding work (e.g. tank cleaning, navigation through congested waters).

.3 Managing workload and work-pace change caused by machinery breakdowns and planned and unplanned sicknesses and illnesses.

.4 Where practicable, minimizing routine and administrative tasks or redesigning them to ensure seafarers can focus on core duties in their working time.

.5 Minimize repetitive or monotonous tasks by using task rotation, where practicable.

.6 Where practicable, defer non-urgent work to allow appropriate rest and recovery if necessary.

Work and living environment

35 The work and living environment is important for ensuring adequate opportunity for sleep and should be considered. Because good quality sleep is critical, companies should develop procedures to minimize interruptions to seafarers' sleep. Opportunities for implementing countermeasures in this area vary from shipboard environmental, procedural to operational changes. For example, most environmental aspects such as noise can be better addressed during ship design (see module 5). However, there are control measures that the company can implement to assist in reducing noise levels in the sleeping environment.

36 Environmental, procedural and operational measures may also range from low-cost solutions, such as porthole blinds and door baffles, to high-cost solutions, such as refitting the ship exhaust or air conditioning systems.

37 Operational and procedural changes may include developing napping policies or defining blocks of time (sleep opportunities) during which seafarers are not contacted except in emergencies. These protected sleep opportunities need to be known to all relevant personnel. Depending on the situation, changes should be made to those areas that will have the most impact, and following evaluation, consideration to other changes can then be made.

38 Environmental control measures may include, but are not limited to:

.1 adequate facilities for rest, sleep and meal breaks and other essential requirements, such as bathroom facilities and personal storage;

.2 making sleeping areas darker, quieter and more comfortable and increasing lighting in certain areas of the ship, such as:

.1 providing a dark sleeping atmosphere using blackout blinds for portholes or berths in sleeping spaces;

.2 installing insulation baffles over cabin door louvres;

.3 improving air conditioning (ambient temperature) and air flow; and

.4 supplying good quality and comfortable bedding such as mattresses and pillows;

.3 making sleeping spaces, including their location, a priority in retrofitting and new ship construction; and

.4 ensuring adequate personal storage space is available for seafarers' personal effects.

39 Procedural and operational control measures may include, but are not limited to:

.1 increasing access to healthier food choices by ensuring nutritious food is served on board;

.2 providing information and advice on healthy eating and physical well-being;

.3 making exercise equipment and facilities available to seafarers;

.4 providing and maintaining a quiet atmosphere for sleep; develop a "do not disturb" policy for sleeping seafarers;

.5 where practicable, calls for drills should be conducted in a manner that minimizes the disturbance of rest periods as they can be extremely disruptive;

.6 putting in place short breaks within duty periods, including napping policies;

.7 ensuring ship routines such as meal times are commensurate with seafarer working schedules; this includes providing personnel working at night with appropriate meal choices;

.8 providing access to counselling services to assist in any issues arising from the disruption to individual, family or social patterns and shipboard-related aspects; implement a consistent stress management programme;

.9 have a policy in place to support seafarers experiencing elevated levels of workload;

.10 if possible, avoid assigning seasick and ill seafarers shipboard work;

.11 if possible, provide all seafarers with shipboard phone, internet and email access; and

.12 if possible, ensure that maintenance work does not disrupt personnel sleeping.

Adequate sleep obtained

40 Given that sleep loss is a primary contributor to fatigue, the company should determine whether adequate sleep is obtained.

41 Situations may arise where a seafarer is provided with an adequate sleep opportunity, but they may not get adequate sleep. Hence, while an adequate sleep opportunity provides an indication of the quantity of sleep likely to be obtained, it is important to know whether adequate sleep has actually been obtained. Seafarers should be provided with the opportunity to report situations when they have been unable to obtain adequate sleep or feel at risk of making fatigue-related errors without repercussions.

42 In general, seafarers are responsible for using adequate sleep opportunity appropriately, so they are alert and capable of performing assigned shipboard work safely. However, there are a number of reasons why seafarers may not obtain adequate sleep. The aspects mentioned below can all affect the amount and quality of sleep obtained:

.1 a seafarer working during the night may have difficulty getting quality sleep;

.2 a seafarer upon joining the ship may experience difficulty adjusting to the sleep schedule;

.3 a seafarer travelling for an extended time to the ship should not be required to report to work until adequate rest is obtained;

.4 undiagnosed and untreated sleep disorders as highlighted in module 1;

.5 emotional stress;

.6 the sleeping environment (comfort, noise, darkness, ship motion, privacy, room location) may not allow for adequate sleep;

.7 the type of food consumed;

.8 medication or use of prescribed/over-the-counter/natural remedies;

.9 consumption of stimulants such as caffeine and amphetamines; and

.10 use of personal electronic devices before sleep, which may delay the onset of sleep and not allow adequate sleep to be obtained.

43 Regardless of the circumstances causing insufficient or poor quality sleep, these should preferably be identified through proactive measures and treated as a potential shipboard hazard.

What rules and regulations are in place to prevent and deal with fatigue (international, national and company)?

44 Reference is made to the instruments mentioned in module 1.

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MODULE 3

FATIGUE AND THE SEAFARER

1 Module 3 contains practical information intended for the seafarer (master, officers, ratings and all other shipboard personnel) working on ships. Prior to reviewing this module, it is strongly recommended that all seafarers become familiar with module 1 (Fatigue) first. Management-level seafarers (master and officers) should also become familiar with module 2 (Fatigue and the company).

2 Although the company is primarily responsible for creating a work and living environment that minimizes fatigue-related risks, seafarers are responsible for ensuring that time available for rest and sleep is used appropriately and that their behaviour does not create or increase risk.

3 The maritime industry operates a variety of work schedules in a wide range of operational environments, which means that at some point seafarers are likely to experience fatigue. Fatigue affects all individuals, regardless of skill, rank, knowledge or training.

How to recognize fatigue (signs/symptoms)?

4 Fatigued individuals are poor judges of their own level of fatigue and performance because fatigue affects their ability to make judgements or solve complex problems.

5 Fatigue-related signs and symptoms are often divided into three categories: cognitive, physical and behavioural (see table 1 in module 1). Seafarers may recognize some of these in others and, with time, lessons can be learnt to identify some within themselves. These signs and symptoms of fatigue may be used to identify an individual's level of alertness.

6 Some of the more apparent signs and symptoms include:

.1 cognitive:

.1 focuses on a trivial problem, neglecting more important ones;

.2 slow or no response to normal, abnormal or emergency situations;

.3 lapses of attention;

.4 poor judgement of distance, speed, time, etc.;

.5 forgets to complete a task or part of a task; and

.6 difficulty in concentrating and thinking clearly.

.2 physical:

.1 inability to stay awake (an example is head nodding or falling asleep involuntarily);

.2 difficulty with hand-eye coordination skills (such as switch selection);

.3 speech difficulties (it may be slurred, slowed or garbled);

.4 increased frequency of dropping objects like tools or parts; and

.5 digestion problems;

.3 behavioural:

.1 decreased tolerance and/or anti-social behaviour;

.2 irregular/atypical mood changes (examples are irritability, tiredness and/or depression)

.3 ignores normal checks and/or procedures; and

.4 increasing omissions, mistakes, and/or carelessness.

7 Long-term effects of sleep loss may lead to cardiovascular diseases, gastrointestinal diseases, mental health problems and stress.

8 The more signs and symptoms seafarers observe in others and/or experience themselves, the more likely it is that alertness is significantly reduced. Fatigue is not the only cause of such symptoms, but when several occur together, it is likely to indicate fatigue-related impairment. It is important that seafarers notify crewmates and supervisors when they recognize that they or other crew members are fatigued. It is important to have open communication between seafarers, their crewmates and their supervisors regarding fatigue prevention and detection. The company's fatigue risk mitigation strategy should allow for open communication and reporting between seafarers, their supervisors and management levels regarding fatigue prevention and detection, and should prohibit any action directed against a seafarer for such communications or reports.

What can seafarers do to help reduce and manage the risk of fatigue on ships?

9 Obtain adequate sleep: The most effective strategy to fight fatigue is to obtain adequate quality, quantity and continuity of sleep. As indicated in module 2, the company should provide seafarers with an adequate sleep opportunity for recovery. Insufficient sleep over several consecutive days will impair alertness; only sleep can maintain or restore performance levels.

10 Sleep is most valuable if obtained in a single block. While a short sleep or nap can provide a powerful boost in alertness, it does not eliminate the need for longer periods of sleep.

11 There may be instances when seafarers may not obtain adequate sleep, even though they are provided with adequate sleep opportunity. The items mentioned below can all affect the quantity and quality of sleep obtained:

.1 seafarers are working during the night and may simply be unable to sleep during the day;

.2 seafarers' sleep may have been interrupted by colleagues, unexpected events or operational demands;

.3 seafarers may suffer from a sleep disorder, or other medical or physical problem that keeps them awake;

.4 emotional stress due to personal circumstances including family problems at home;

.5 inability to get to sleep due to concerns about work or other worries;

.6 the sleeping environment (comfort, noise, darkness, ship motion, privacy) may not allow for adequate sleep;

.7 the type of food consumed;

.8 medication or use of prescribed/over-the-counter/natural remedies;

.9 consumption of stimulants, i.e. caffeine, amphetamines, energy drinks;

.10 consumption of alcohol;

.11 use of electronic devices which emit blue light (e.g. smartphones, tablets, computer screens) have been shown to adversely affect the onset of sleep;

.12 adjusting to a new watch schedule and recovering from jet lag; and

.13 social activities or high excitement just before sleep period.

12 Regardless of the circumstances causing insufficient or poor quality sleep, these should preferably be identified through proactive measures and treated as a potential shipboard hazard.

13 The company should have processes in place to provide seafarers with the opportunity to report situations when they have been unable to obtain adequate sleep or feel at risk of making fatigue-related errors, specifically if conducting safety critical tasks, without fear of reprisal. This can be as simple as verbally reporting to supervisors, management levels and/or the ship's safety committee.

14 Some general guidance on developing good sleep habits is given below:

.1 if possible, develop consistent sleep times, i.e. try to go to bed at the same time every day;

.2 develop and follow a pre-sleep routine to promote sleep at bedtime, e.g. a warm shower, reading calming material or just making a ritual of pre-bed preparation;

.3 get sufficient sleep, especially before a period when time for adequate sleep may not be available;

.4 avoid stimulating activities prior to sleep such as exercise, television and movies;

.5 make the sleep environment conducive to sleep (a dark, quiet and cool environment and a comfortable bed encourages sleep); a white noise generator or earplugs can be of use if you find them helpful; block out as much light as possible; this might involve the use of blackout curtains, roller shutters, heavy blinds or an inexpensive option such as black plastic; a sleep mask can also be used;

.6 as much as possible, ensure there will be no interruption during your period of sleep;

.7 avoid alcohol, caffeine and other stimulants prior to sleep (keep in mind that coffee, tea, colas, chocolate and some medications, including cold remedies and aspirin, contain alcohol and/or caffeine); avoid caffeine at least four hours before bedtime

.8 relaxation techniques, such as meditation, may help;

.9 do not nap if you have difficulty sleeping during your normal sleep period;

.10 avoid eating right before sleeping; and

.11 limit the use of electronic devices that emit blue light prior to bedtime.

Maintain fitness for duty

15 Ensuring that seafarers are fit for duty and able to maintain safe levels of alertness and performance is important. Taking responsibility for seafarers' duty schedules and rest periods and providing feedback to their supervisors, management levels and the company is important to ensure that seafarers are provided with the best possible opportunity to maintain fitness for duty.

16 In some cases, monitoring and assessing seafarers' level of fatigue prior to their duty schedule can be helpful in ensuring they are able to perform tasks safely. There are a number of tools that can be used to assess how seafarers feel prior to and during their duty period, such as self-monitoring or fatigue assessment tools. It is important to report (to seafarers' supervisors and/or management levels) any instances in which seafarers feel that safety could have been or will be compromised due to fatigue impairment in either themselves or their peers.

17 Some general guidance that may help seafarers maintain fitness for duty is given below:

.1 take strategic naps (the most effective length of time for a nap is about 20 minutes);

.2 take advantage of scheduled breaks;

.3 whenever possible, monitor and effectively manage sleep;

.4 whenever possible, maintain and monitor fitness for duty including medical fitness;

.5 report any fatigue impairment in yourself and in others that may have the potential of affecting ship safety;

.6 record and report actual hours of work and rest as required by the MLC and the STCW Convention;

.7 eat regular, well-balanced meals;

.8 exercise regularly; and

.9 limit the use of medications that may affect levels of alertness and performance, including seasickness medications (if such medications are used, shipboard supervisor should be informed accordingly).

18 A number of countermeasures have been identified as potentially providing some relief in managing fatigue. It must be emphasized that these countermeasures will not restore an individual's state of alertness; they only provide short-term relief and may, in fact, simply mask the symptoms temporarily. At some stage, sleep must be obtained for physical and mental recovery to occur. The following list captures some of these short-term countermeasures:

.1 **Short rest breaks within duty periods**

Rest, apart from sleep, can be provided in the form of short breaks or changes in activities during the duty period. Rest breaks may be helpful if performance is to be maintained over long periods of time. Factors influencing the need for rest are the length and intensity of the activities prior to a break or a change in activity, the length of the break, or the nature or change of the new activity. It is recognized that in a shipboard environment this may not always be feasible; however, short breaks should be planned into the duty period as much as possible.

.2 **Strategic napping**

A short sleep or nap can provide a powerful boost to alertness. Research has identified strategic napping as a short-term relief technique to help maintain performance levels during long periods of wakefulness. Naps as short as 10 to 15 minutes are known to deliver measurable benefits. Naps are helpful in maintaining performance if sufficient longer sleep is occasionally missed. The most effective length of time for a nap is about 20 minutes. It is recommended that seafarers take naps in the way that they believe best suits them. Napping should be encouraged to be a planned activity of fatigue management and prevention. This means that if seafarers have the opportunity to nap they should take it. However, there are some drawbacks associated with napping. One potential drawback is that naps longer than 30 minutes will cause sleep inertia, where situational awareness is impaired (grogginess and/or disorientation for up to 20 minutes after waking). A second potential drawback is that the nap may disrupt later sleeping periods (a person may not be tired when the time comes for an extended period of sleep).

.3 **Caffeine**

Another popular fatigue countermeasure is the strategic use of caffeine (encountered in coffee and tea, and to a lesser extent in colas and chocolate) as a stimulant. Caffeine can improve alertness temporarily but it is not a substitute for adequate sleep and rest. It takes caffeine 15 to 30 minutes to take effect and caffeine levels drop by half every five or six hours. Its effects can last long after consumption and may interfere with needed sleep. It is important to consider, however, that there are individual differences in terms of how the effects of caffeine, tolerance and withdrawal develop. Caffeine should be avoided before bedtime. In addition, regular usage over time reduces its value as a stimulant and may increase tiredness and reduce

ability to sleep. Caffeine consumption can also cause other side effects such as hypertension, headaches, mood swings and anxiety.

.4 **Nutrition and hydration**

Adequate nutrition and hydration is important for managing and preventing fatigue. Ideally, one should have a balanced diet, eat regularly, have healthy snacks, plan meals, drink water regularly and avoid meals just before bedtime (as eating just before bedtime results in slower digestion). The recommended daily intake of water is two litres or eight glasses. Monitoring one's fluid intake helps to optimize alertness and wakefulness.

.5 **Environment** (light, temperature, humidity and sound)

Bright lights, cool dry air, obtrusive or loud music or other annoying irregular sounds may temporarily increase alertness.

.6 **Physical activity**

Physical well-being has a number of key components, notably exercise, diet, hydration and sleep. Any type of physical activity helps to maintain alertness; running, walking, stretching or even chewing gum can stimulate the level of alertness. Exercise can also improve sleep. Proper physical self-care results in a range of positive outcomes including reserves of energy during the duty period, consistent and restful sleep patterns, proper concentration spans and a satisfying sense of feeling healthy. The benefits of regular exercise include improved mood, better stress coping, and enhanced self-esteem and well-being.

.7 **Social interaction**

Social interaction (conversation) can help one stay awake. However, the conversation should be interactive to be effective.

.8 **Job rotation when practicable**

Changing the order of activities can be beneficial in breaking up job monotony. Mixing tasks requiring high physical or mental work with low-demand tasks can be beneficial.

19 When feeling fatigued, seafarers may engage in individual fatigue countermeasures, such as walking around, using caffeine or stimulants, to reduce the likelihood of fatigue-related errors. However, there may be instances when high levels of fatigue cannot be mitigated by individual countermeasures. Hence, prompt, consistent and appropriate action is required (by the management-level seafarers through company support) whenever a seafarer is potentially not fit for duty. This may include the need for additional actions, such as task rotation and additional supporting resources, for managing fatigue-related risks. The aim should be to maintain and promote safety.

What are the seafarer's responsibilities in fatigue risk management on ships?

20 The particular nature of fatigue as a safety hazard makes managing shipboard fatigue and associated risks the shared responsibility of the company and the seafarer. As highlighted in other sections, there are a number of measures that can be taken to mitigate the risk of

fatigue. Many of the measures are unfortunately beyond a single person's ability to influence, such as voyage scheduling, ship design and work scheduling.

21 Seafarer responsibilities include:

.1 doing their best to commence duty schedule in a fit state to work the expected duty length and perform assigned shipboard work safely;

.2 monitoring and effectively managing hours of sleep;

.3 reporting fatigue-related hazards that affect safety;

.4 maintaining appropriate communication about safety;

.5 being aware of fatigue and how to counter its effects; and

.6 using available rest periods appropriately, in addition to using personal fatigue mitigation strategies.

22 Seafarers are responsible for monitoring and seeking appropriate treatments for any health concerns that may impact their fitness for duty. Seafarers' well-being can be affected by a variety of factors including health conditions, genetic predispositions, nutrition, hydration and sleep difficulties. A wide range of sleep difficulties can affect fatigue, circadian rhythm, sleep duration and sleep quality. This includes a diversity of sleep disorders as indicated in module 1.

23 Module 2 provides recommended strategies for the company to manage the risks of fatigue at sea. Some important aspects related to company responsibility include:

.1 developing policies and practices within the ship's safety management system to manage fatigue-related risks;

.2 developing work schedules that prevent high levels of fatigue during duty periods;

.3 developing work schedules that allow for adequate rest and recovery periods between duty schedules (if possible allow for an anchor sleep period of seven to eight hours);

.4 implementing appropriate and safe duty/watch periods taking into account circadian rhythms;

.5 providing an adequate sleep environment on the ship;

.6 ensuring all seafarers are trained and aware of the causes and consequences of fatigue;

.7 promoting a safety reporting culture with open communication and no fear of reprisal; and

.8 continuously assessing, controlling, monitoring and evaluating fatigue-related hazards.

What can management-level seafarers do to reduce and manage the risk of seafarer fatigue on ships?

24 The following provides a recommended list of important fatigue management strategies in controlling and reducing the risk of fatigue on board ships, and are within the management-level seafarer's ability to influence and/or implement:

.1 ensuring, as a minimum, compliance with minimum hours of rest and/or maximum hours of work;

.2 using rested personnel to cover for those travelling long hours to join the ship, e.g. allowing proper time to overcome fatigue and become familiarized with the ship;

.3 managing the amount of time seafarers need to spend performing physically and mentally demanding work for a sustained period of time (e.g. tank cleaning, navigation through congested waters);

.4 ensuring nutritious food options are served on board and seafarers have continuous access to drinking water;

.5 providing night-time personnel with appropriate meal choices;

.6 maintaining interaction between shore management and ship management with respect to fatigue awareness and preventive measures on board the ships;

.7 creating an open communication environment, by making it clear to the crew members that it is important to inform supervisors when fatigue is impairing their performance or that of others and ensuring that there will be no recriminations for such reports;

.8 ensuring that selected seafarers can do the job for which they are assigned to prevent the potential for fatigue in other crew members;

.9 improving shipboard conditions to ensure that when there is an opportunity to sleep, crew members can take advantage of it without interruptions, e.g. by scheduling drills and routine maintenance functions in a manner that minimizes the disturbance of rest/sleep periods; all relevant seafarers should be aware of these protected sleep opportunities;

.10 establishing onboard management techniques when scheduling shipboard work and rest periods and when scheduling work practices and assignment of duties in a more efficient manner;

.11 if practicable, assigning work by mixing up tasks to break monotony and to combine work requiring high physical or mental demand with low-demand tasks (job rotation);

.12 avoiding scheduling potentially hazardous tasks during the circadian lows of the seafarers involved, when practicable;

.13 providing support for seafarers to recognize and deal with the effects of fatigue including onboard training, if provided;

.14 emphasizing the seafarer's responsibility to sleep during rest periods to ensure that adequate sleep is obtained;

.15 taking time to monitor that all personnel are getting adequate sleep;

.16 ensuring that shipboard conditions, within the seafarer's ability to influence, are maintained in a good state, e.g. maintaining the heating, ventilation and air conditioning on schedule, light bulbs are replaced and sources of unusual noise are taken care of at the first opportunity;

.17 reappraising work patterns and areas of responsibility on board to establish the most efficient utilization of resources (such as sharing the long cargo operations between all the deck officers instead of the traditional pattern and utilizing rested personnel to cover for those who have travelled long hours to join the ship);

.18 promoting supportive relationships on board (good morale) and dealing with interpersonal conflict between seafarers;

.19 establishing shipboard practices for dealing with fatigue incidents and learning from them, e.g. as part of the safety meeting;

.20 increasing awareness of the benefits of a healthy lifestyle, e.g. exercise, relaxation, proper nutrition;

.21 timely coordination of scheduled activities between the company, management-level seafarers and other stakeholders; and

.22 allowing time for communication at watch/work handovers.

What rules and regulations are in place to help manage fatigue?

25 Reference is made to the instruments mentioned in module 1.

26 In addition to the international standards, company and flag Administration policies, which may be more stringent in some cases, should be followed on board all ships.

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MODULE 4

FATIGUE AWARENESS AND TRAINING

1 This module builds upon the previous modules and contains practical information on fatigue awareness and training intended for those involved in fatigue awareness and related training. It is recommended that those involved in fatigue awareness and training become familiar with all the other modules.

What are the objectives of raising awareness and training on fatigue?

2 Fatigue training and awareness are essential components for effective fatigue management. Fatigue management should be taught in such a way that seafarers can understand and relate to it personally. Seafarers will at some point be required to make operational decisions based on their knowledge of fatigue. Hence, all personnel who work on ships, and shore-based personnel who contribute to fatigue management in the company, should have appropriate training.

3 Some onboard fatigue mitigation strategies lie outside the power of most individuals to implement (such as ship manning levels, the rearrangement of watches, changing ship design or modifying voyage schedules). Hence, fatigue awareness and training should not just be limited to seafarers but should also include shore-based personnel involved in overall operational risk assessment and resource allocation, including manning levels, on ships.

4 The content of fatigue management training should be adapted according to the knowledge and skills required for each group. All groups should be educated in the basics about the dynamics of sleep loss and recovery, the effects of the daily cycle of the body clock, the influence of workload and the ways in which these factors interact with operational demands to produce fatigue. In addition, it is useful for all groups to have information on how to manage their personal fatigue and sleep issues.

5 The objectives are to provide:

.1 an awareness of fatigue and an acceptance that everyone experiences fatigue – it is not a personal shortcoming or weakness;

.2 know-how about short- and long-term fatigue signs and symptoms, including its effects and possible preventive and mitigating measures; and

.3 the ability to develop and implement fatigue management strategies for preventing or minimizing fatigue on board.

What approaches and techniques are successful for teaching fatigue management?

6 Training in the causes and management of fatigue extends from the underlying science (module 1) to mitigation, control and monitoring (modules 2, 3 and 5). It is taught as part of existing maritime training courses such as Basic training, Engine-room resource management, or Bridge resource management, or as specialized short courses. It can be taught ashore or on board. It can be included in refresher or revalidation training.

7 Part of the education process should be to ensure that seafarers and shore-based personnel who contribute to fatigue management understand the necessity of getting regular rest and sleep, and the potential impacts of being fatigued (both on themselves and on the safety of the ship and/or those working with them).

8 Training should include recognizing the symptoms of fatigue and developing preventive measures/mitigating techniques. Earlier modules should be utilized to specifically tailor the training to the audience. Areas covered can include the causes, symptoms, effects, prevention and mitigation factors, including rules and regulations concerning fatigue.

9 Initial fatigue-related training efforts should establish a common base level of understanding among seafarers and shore-based company employees about fatigue and the impairment it causes. This training should be provided to all seafarers and shore-based personnel involved in resource allocation, including manning decisions.

10 As a minimum, training should consist of:

.1 fatigue, its causes and potential consequences (contributors, consequences, high-risk situations);

.2 sleep (circadian rhythms, body clock, sleep process, circadian low, sleep debt, sleep disorders, working at night and watchkeeping);

.3 fatigue countermeasures (e.g. mitigation strategies, managing sleep habits, caffeine, nicotine, alcohol, nutrition, exercise, napping, rest breaks);

.4 basic information on sleep disorders and treatment of them, where to seek help if needed and any requirements relating to fitness for duty;

.5 an understanding of the rules and regulations dealing with fatigue (MLC, 2006 and STCW Convention), and a recognition that these represent one line of defence in managing the risk of fatigue;

.6 how to identify fatigue in oneself and in others;

.7 personal strategies that seafarers can use to improve their sleep and to minimize their own fatigue risk, and that of others, while they are on duty;

.8 the responsibility of the company to provide, and of seafarers to take advantage of, adequate rest periods;

.9 the responsibility of the seafarer to report situations when unable to obtain adequate sleep or feeling at risk of making fatigue-related errors; and

.10 the responsibility of the company to have policies in place to appropriately manage fatigue risks including policies against retaliation for reporting.

11 Decisions on watch schedules can affect fatigue, hence training and awareness about factors that contribute to fatigue and how duty and watch schedule design is crucial to fatigue management should be part of more comprehensive training. This training should be directed at shipboard management-level seafarers and shore-based personnel involved in resource allocation including manning.

12 As a minimum, training for these personnel should comprise of:

.1 seafarer training on fatigue as indicated above;

.2 their role in relation to fatigue hazard identification, risk assessment, evaluation and reporting;

.3 how scheduling affects sleep opportunities and can disrupt the body clock, the fatigue risk that this creates and how it can be mitigated through proper work scheduling (in particular, the timing of duty schedules, work duration, recovery time between duty periods, recovery time between watch schedules and the potential impact that unscheduled or planned changes can have on fatigue);

.4 the use and limitations of any duty and watch scheduling tools and models for fatigue management;

.5 the development of policies and processes to provide the opportunity to report fatigue situations without negative consequences; and

.6 the provision of resources as outlined in other modules (lighting, food/diet, environmental, etc.) to manage fatigue.

What can be learned from experience?

13 Lessons learned provide a means to develop useful strategies to prevent or minimize fatigue. The instructor should review the previously shared personal experiences and direct the conversation toward the lessons learned or strategies, as students see them. The focus should be on appropriate case studies and specific experiences within the seafarer's workplace to show what fatigue management practices may be adopted.

14 Trainees will have their own personal experiences and perceptions of fatigue and how to mitigate it. It is important to share a common understanding on fatigue issues and on its management. Ideally, this knowledge will be put into practice at the workplace.

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MODULE 5

FATIGUE AND SHIP DESIGN

1 Module 5 highlights human fatigue mitigation measures which may be utilized in the specification and design of ships, their living and working spaces and their machinery installations. Module 1 (Fatigue) should be read prior to going through this module.

2 The design principles for fatigue mitigation and management should be considered early in the design process.

3 Fatigue is a hazard that affects safety, health and well-being. It presents a considerable risk to safety of life, property, health, security and protection of the marine environment. Because seafarers live and work aboard ships, sometimes for an extended period of time, they may be exposed to conditions that cause fatigue. Therefore, the design, layout and arrangement of working and living areas should be considered as part of mitigating and managing the risk of fatigue on board ships.

4 Shipboard ergonomics and the environmental conditions on board are important considerations in ensuring seafarers are provided with the best opportunity to:

.1 maintain safe levels of alertness and performance during work periods;

.2 maintain good health and resilience to fatigue through the provision of adequate rest, recreational and exercise facilities; and

.3 obtain adequate restorative sleep; as highlighted in module 1, inadequate restorative sleep (both quantity and quality) is among the main causes of fatigue and can be affected by the living and working environment on board.

What aspects of ship design can influence fatigue?

5 There are various aspects of fatigue that can potentially be influenced by the design of the living, sleeping and working environment. Fatigue can be caused by excessive noise, heat or cold, light, too much or too little humidity and poor air quality, among others, where people live and work.

6 Sleeping, living and working areas should be located within the ship to minimize undesired motions, vibrations and noise.

7 Appropriate noise levels (SOLAS regulation II-1/3-12) support effective communication and reduce mental workload while on duty, and enhance quality of sleep and rest when off duty. Noise and vibration prediction modelling efforts should be done early in the vessel design process to ensure the most effective design and layout for noise and vibration control and mitigation. See also paragraph 31.3 below, which refers to the *Code on noise levels on board ships* (resolution MSC.337(91), which is mandatory for some types and sizes of ships.

Accommodation spaces and layout design (design to promote rest and well-being)

8 Crew accommodation is often located in positions likely to be affected by machinery-induced noise and vibration (including cargo transfer systems) and propeller-induced noise and vibration. Steps should be taken early in the design stage to alleviate this. Noise sources internal to the accommodation also need to be considered and noise levels generated by the heating, ventilating and air conditioning (HVAC) systems should be controlled.

9 Sources of intermittent machinery-induced noise and vibration caused by machinery stopping and starting on a cyclical or irregular basis should also be considered.

10 Measures to reduce disturbance from impact noise from human activity in corridors and service spaces above and/or adjacent to accommodation should be incorporated in the ship design.

11 Consideration should be given to:

.1 ensuring cabins are cool, quiet, dark and well ventilated;

.2 bunk design, layout and orientation;

.3 mattress, bedding, padding for ship movement, headroom clearance especially upper bunk/deckhead;

.4 insulating and/or isolating sleeping areas;

.5 use of colour and artwork in the cabins; and

.6 use of acoustic insulation and/or other noise-abatement measures.

12 Notwithstanding the above, consideration should be given to sounds that need to be heard, e.g. fire alarms.

13 Consideration should also be given to providing an accommodation area that is conducive to rest and that aids recovery. As far as reasonably practicable, the following should be considered:

.1 design for minimal crew flow in sleeping quarters;

.2 laundry, changing, hygiene, privacy;

.3 insulation or isolation from cargo, engine, other disturbances (noise and vibration);

.4 design lighting to support day and night sleep (lighting/dimmers and block-out);

.5 ventilation/air quality;

.6 temperature locally adjustable and humidity (design for sleep); and

.7 location and layout of galley and mess room(s).

14 It is also important to consider design for recreation and recovery. Aspects to consider include:

.1 range of needs (personality and culture);

.2 privacy and social life;

.3 minimal housekeeping;

.4 gym/training facilities; and

.5 library, media rooms, ease of study.

Workplace design (design for alertness and performance)

15 Workplace design, particularly for tasks that require sustained physical or mental exertion, should consider the following aspects:

.1 design of the workplace and workflow for optimum layout (placement, storage, adjustable, visibility, ease of communication, ease of movement, noise, vibration, temperature, humidity);

.2 working position (seated/standing, height, flooring material (shock and balance);

.3 usability (displays and controls incorporate ergonomic and task requirements);

.4 protection from hazards (e.g. provide suitable hand holds, barriers, signs, stairs and surfaces to allow easy movement in bad weather);

.5 design lighting for work spaces to support alertness (colour, natural light access, bright light); and

.6 maintenance – design for maintainability (access envelopes accounting for required tools and motions, etc.).

16 Additionally, design of control centres such as machinery control room layout, cargo control room layout and the bridge, should consider the integration of people with equipment and systems to enhance system resilience to crew fatigue, as well as reducing mental overload and boredom.

How can ergonomics support the mitigation and management of fatigue on ships?

17 Ergonomics/human factors are defined as the scientific discipline concerned with the understanding of interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

18 Ergonomically designed work systems enhance safety, effectiveness and efficiency. They support shipboard tasks under all conditions, including situations where people may be fatigued.

19 The ergonomics approach to design is human-centred. This means that all designable components (e.g. ship, ship's systems, equipment, service) are fitted to the characteristics of the intended users, operators or workers (e.g. seafarers, maintainers) rather than selecting and/or adapting humans to fit the system and/or product. This should be done by considering:

.1 the intended target population;

.2 the task, goal or intended outcome of the system, product or service; and

.3 the environment in which the design is to function.

20 Both the needs and limitations of the end users (e.g. seafarers, maintenance or repair teams) should be considered during the design of ship systems and equipment. Those with experience and knowledge of the requirements of ship systems and equipment should be consulted, as far as possible, during the design and construction phases of new ships. Early

and continued participation and involvement is regarded as an efficient design strategy, especially within ergonomics, since, in addition to improving the design, it reduces late-stage re-work and increases user acceptance.

21 Ergonomic design is task-oriented: it takes into account differences that can be observed between the designed task and the way the task is actually performed. Activities in performing a task are affected by variations and changes in context, procedures, equipment, products or materials, for example.

22 The relations between the conditions and demands placed on the seafarer and their response to being exposed to such conditions and their effects need to be considered in the design of ship systems, services, products and tasks in order to avoid impairing effects on the individual. The response to conditions and demands is dependent on individual characteristics (e.g. body size, age, capacities, abilities, skills).

23 Standards are available giving guidance on how to incorporate ergonomics into the design process, e.g. ergonomic principles in the design of work systems. A list of appropriate standards are included in the reference list.

What tools are available for designing/building fatigue resistant ships?

24 The application of ergonomic standards and guidance is effective for improving the working environment, particularly those that deal with environmental conditions (such as temperature, noise, vibration, ventilation).

25 Computer simulation tools can be used to support ergonomic design. These are increasingly being used to assess both the impact of environmental conditions as well as work and living design ergonomics. Examples include virtual reality and three-dimensional computer aided design. Use of simulation tools is encouraged as they allow early and more cost-effective evaluation of various aspects of design. There are a variety of design tools that can be applied early in the design process to assist the ship designer in ensuring that specified limits are not exceeded. Wherever possible, and if available, anthropometric data and standards should be utilized to support ergonomic design.

26 Environmental conditions also extend across structural design, propulsion, hull forms and several other aspects of design. Often, constructional solutions may be employed to improve environmental conditions. For example, the transmission of noise can be reduced by the insertion of acoustic insulation; similarly, structural resilience techniques can be used to alleviate vibration problems.

27 Use of Finite Element Analysis (FEA) and noise and vibration prediction tools to reduce noise and vibration is generally more cost-effective than post-construction noise and vibration mitigation.

28 Similarly, seakeeping prediction tools may be used, together with ship and propeller model testing, to predict velocity and acceleration levels that can affect habitability.

What rules and guidance are available for designing/building a fatigue resistant ship?

29 There are a number of rules, regulations, standards and guidelines designed to enhance environmental shipboard conditions, which can be used by the ship designer to reduce fatigue. This is a developing field and the designer should check for new material.

30 Some aspects of crew accommodation are subject to regulations under the International Labour Organization's Maritime Labour Convention (MLC), 2006, in particular Title 3 (Accommodation, recreational facilities, food and catering). Crew accommodation is also subject to national standards. Classification societies have guidance and optional notations for aspects of environmental conditions (e.g. noise and vibration) for certain ship types (see reference section for examples). Designers are encouraged to refer to the relevant guidelines.

Noise and vibration

31 IMO has implemented requirements and resolutions aimed to protect the seafarer from unacceptable levels of noise:

.1 SOLAS regulation II-1/3-12 (Protection against noise).

.2 *Code on noise levels on board ships* (resolution MSC.337(91)) (this Code is mandatory under SOLAS regulation II-1/3-12, which entered into force on 1 July 2014); and

.3 *Code on noise levels on board ships* (resolution A.468(XII)) fixes permissible maximum limits of noise depending on the type of space.

32 In addition, MLC, 2006, Title 4 addresses noise and vibration. Relevant ISO/IEC standards on noise and vibration should also be considered throughout the design process (see references).

Working spaces

33 Regulations and standards exist for dealing with improvements to working spaces which may help in reducing fatigue and its effects. These are developed by organizations such as IMO, ISO/IEC and classification societies. Reference to these standards in ship design is encouraged (see reference section).

References

1 American Bureau of Shipping (ABS), *Guidance Notes on Noise and Vibration control for inhabited spaces*. September 2017.

2 American Bureau of Shipping (ABS), *Guidance Notes on the Application of Ergonomics to Marine Systems.* February 2014. ww2.eagle.com

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4 Calhoun, S. R., (2006). *Human Factors in Ship Design: Preventing and Reducing Shipboard Operator Fatigue*, in *Department of Naval Architecture and Marine Engineering*, University of Michigan.

5 ClassNK, *Noise and Vibration Guideline* (2nd Edition), June 2014.

6 ClassNK, *Guidelines for the mandatory Code on noise levels on board ships* (3rd Edition), March 2018.

7 DNV GL Comfort Class: Rules for classification, Ships, Part 6 *Additional class notations, Chapter 8 Living and working conditions,* Section 1 Comfort Class – COMF. 1. January 2017.

8 IMO MSC/Circular.834, *Guidelines for engine-room layout, design and arrangement*.

9 IMO MSC/Circular.982, *Guidelines on ergonomic criteria for bridge equipment and layout.*

10 ISO 11064-1:2000 Ergonomic design of control centres – Part 1: *Principles for the design of control centres.*

11 ISO 1999:2013 Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment loss.

12 ISO 20283 Mechanical vibration – Measurement of vibration on ships:

- Part 2 (2008): Measurement of structural vibration
- Part 3 (2006): Pre-installation vibration measurement of shipboard equipment
- Part 4 (2012): Measurement and evaluation of vibration of the ship propulsion machinery
- Part 5 (2016): Guidance for measurement, evaluation and reporting of vibration with regard to habitability on passenger and merchant ships.

13 ISO 2631 (Series) Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration.

14 ISO 26800:2011 Ergonomics -- General approach, principles and concepts.

15 ISO 6385:2016 Ergonomics principles in the design of work systems.

16 ISO 6954:2000 Mechanical vibration and shock – Guidelines for the overall measurement, reporting and evaluation of vibration with regard to habitability on passenger and in merchant ships.

17 ISO 8468:2007 Ships and marine technology – Ship's bridge layout and associated equipment - Requirements and Guidelines.

18 ISO 9241-110:2006 Ergonomics of human-system interaction – Part 110: Dialogue principles.

19 ISO 9241-210:2010 Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems.

20 ISO 9241-5:1998 Ergonomic requirements for office work with visual display terminals (VDTs) – Part 5: Workstation layout and postural requirements.

21 ISO 9241-6:1999 Ergonomic requirements for office work with visual display terminals (VDTs) - Part 6: Guidance on the work environment.

22 ISO/TS 20646:2014 Ergonomics guidelines for the optimization of musculoskeletal workload.

23 Lloyd's Register, Rules and Regulations for the Classification of Ships, July 2016 - Part 7 Other Ship Types and Systems – Chapter 12 Passenger and Crew Accommodation comfort.

24 Lloyd's Register, *Ship Vibration and Noise, Guidance* Notes, Rev 2.1, 2006.

25 Lloyd's Register, *The Human-Centred Approach: A Best Practice Guide for Ship Designers*, Lloyd's Register 2014 (available from www.webstore.lr.org Marine/Technical Guides).

MODULE 6

FATIGUE, THE ADMINISTRATION AND PORT STATE AUTHORITIES

1 Module 6 contains practical information intended for Administrations (which means the Government of the State whose flag the ship is entitled to fly) and port State authorities (which means the Government of the State in which the port of call is located). This module provides guidance for considering fatigue in port and flag State requirements, including the impact of their actions on seafarer fatigue and approaches and considerations for mitigating fatigue on board ships. It is also recommended that Administrations and port State authorities become familiar with modules 1 to 5.

Fatigue and the Administration

2 Administrations have an important role to play in mitigating and managing the risks of fatigue at sea.

.1 Implementation and enforcement of international regulations that have a direct impact on mitigating and managing fatigue. These include:

.1 as required under the 1978 STCW Convention, as amended, taking into account the danger posed by fatigue on seafarers, especially those whose duties involve the safe and secure operation of a ship;

.2 taking into account the *Principles of minimum safe manning* (resolution A.1047(27)) when making a determination on safe manning levels for ships flying the Administration's flag;

.3 ensuring that the Administration's ships are appropriately manned in order to encompass all aspects of maintaining safe operations on board and its ships are in compliance with section 6.2 of the ISM Code;

.4 ensuring that all identified risks (including the risk of fatigue) to the Administration's ships, personnel and the environment are assessed and appropriate safeguards established as required under the ISM Code;

.5 ensuring that applicable regulations and requirements affecting fatigue mitigation and management, such as habitability, design, and environmental controls, are complied with; and

.6 ensuring that SOLAS requirements that affect fatigue mitigation and management, such as noise and vibration, are enforced in the design and construction approval.

.2 Consider the impacts on seafarer fatigue as a result of the requirements placed on shipboard operations and seafarers. This includes the impact of:

.1 existing requirements placed on shipboard operations and seafarers; and

.2 proposed new requirements on shipboard operations and seafarers.

.3 Promote these guidelines to all stakeholders, including seafarers, companies, naval architects/ship designers, training providers, Administration officials and any other affected stakeholders.

.4 Promote awareness, education and training on the causes and consequences of fatigue and its management to address the risk (seafarers and companies, lessons learned, etc.).

.5 Incorporate assessment of fatigue in accident/incident investigations. Based on the information received as a result of investigating maritime casualties, Administrations should iteratively evaluate the effectiveness of their fatigue prevention programme(s), if any, and modify as appropriate based on lessons learned.

.6 Encourage companies with ships registered under their flag to incorporate fatigue mitigation and management practices.

.7 Encourage recognized organizations (ROs) with delegated responsibilities to take into account international guidelines and regulations addressing the mitigation and management of fatigue, as appropriate.

Fatigue and port State authorities

3 Port State authorities may also have a role in mitigating seafarers' fatigue. Port State authorities are encouraged to consider the potential effects that inspections and reporting requirements may have on the wider aspect of seafarer fatigue.

4 Port State authorities should consider the impact of inspections, surveys, audits and other visits to ships on seafarer fatigue. This includes considering:

.1 shipboard operations, including work schedules, in the scheduling of inspections, surveys, audits and other visits to ships;

.2 approaches to carrying out inspections, surveys, audits and other visits to ships that minimize the impact on shipboard operations and seafarers; and

.3 the consolidation or coordination of inspections, surveys, audits and other visits to ships, including between different parties, to minimize the impact on shipboard operations and seafarers.

5 Port State authorities should consider the impact of reporting and information requests on seafarer fatigue. This includes considering:

.1 shipboard operations and seafarers when establishing reporting requirements and requesting information from ships and seafarers;

.2 approaches to obtaining reports and information from ships that minimize the impact on shipboard operations and seafarers;

.3 the consolidation or coordination of reporting and information requests, including between different parties, to minimize the impact on shipboard operations and seafarers; and

.4 the harmonization and development of mechanisms to reduce the burdens of reporting and information requests on ships and seafarers.

APPENDICES

APPENDIX 1 Examples of sleep and fatigue monitoring tools

APPENDIX 2 Example of a fatigue event report information

APPENDIX 1

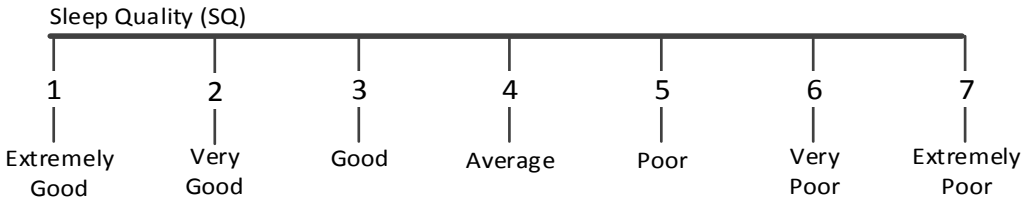
EXAMPLES OF SLEEP AND FATIGUE MONITORING TOOLS

The following examples have been included for personal use as an optional tool to assist individuals in monitoring sleep and fatigue:

- Sleep diary
- Self-monitoring through fatigue and sleepiness ratings
- Fatigue self-assessment tool

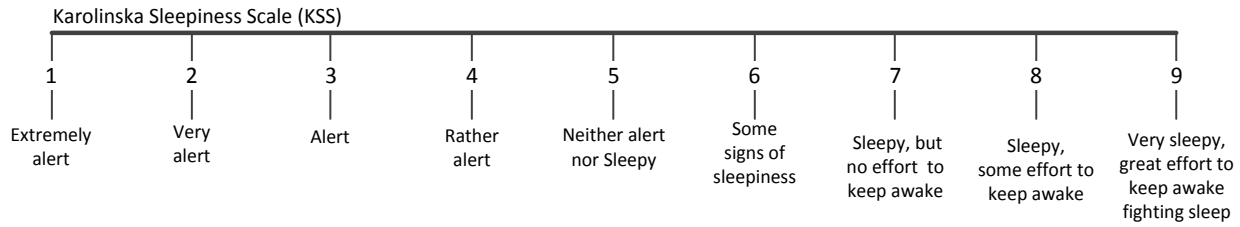
Sleep Diary

Date	I went to bed at:	I got out of bed at:	I slept for a total of (hours):	My sleep quality was (use SQ scale below)	When I woke up I felt (use KSS below)
Day 1 Date:					
Day 2 Date:					
Day 3 Date:					
Day 4 Date:					
Day 5 Date:					
Day 6 Date:					
Day 7 Date:					
Weekly Total					
Daily Average					



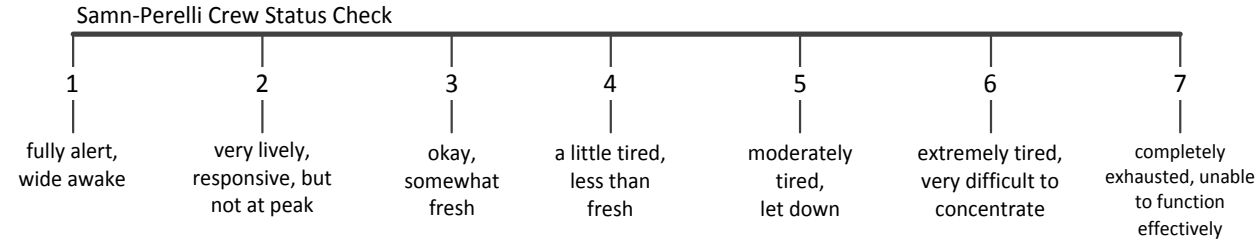
Self-monitoring through fatigue and sleepiness ratings

The Karolinska Sleepiness Scale (KSS)



This scale asks people to rate how sleepy they feel right now. Any of the values from 1 to 9 can be ticked, not only those with a verbal description.

The Samn-Perelli Crew Status Check



This scale asks people to rate their level of fatigue right now, and is a simplified version of the Samn-Perelli Checklist.

Fatigue Self-Assessment Tool

This tool supports the seafarer in the identification of fatigue with an easy-to-use one minute self-assessment. This can be used individually or during handover.

Fitness for Duty	**Do you believe you are fit for duty?**	
	1	No
	2	Yes, with additional risk controls
	3	Yes

Current Fatigue State	**How do you feel right now?**	
	1	Very fatigued, having difficulty staying alert
	2	A bit tired, effort required to stay alert
	3	Very alert – wide awake

Sleep Quantity	**Did you sleep in the last 24 hours?**	
	1	No
	2	Yes, but I did not get my ideal amount of sleep
	3	Yes, I got at least my ideal amount of sleep

Sleep Quality	**How would you rate the quality of that sleep?**	
	1	Poor
	2	Average
	3	Good

Signs of Fatigue	**Have you experienced any physical signs of fatigue immediately before or during this duty period (i.e. microsleeps)?**			
	1	Yes	**3**	No
	Have you experienced any mental signs of fatigue immediately before or during this duty period (i.e. difficulty concentrating)?			
	1	Yes	**3**	No

Adapted from @ Integrated Safety Support, www.integratedsafety.com.au

How to use this tool

With respect to the above questions, the number of the answers indicates the Fatigue Category and the action(s) required in the next table.

- If one or more answer is **1**, your Fatigue Category is **1**.
- If one or more answer is **2**, your Fatigue Category is **2**.
- Otherwise, if your answers are **3**, your Fatigue Category is **3**.

Fatigue Category	Action Required
1	As soon as it is safe to do so, suspend any safety critical tasks that have been started. Report now to your immediate supervisor or master.
2	Before commencing your duty period or assigned tasks, or before continuing work on a task that has been started, report to your immediate supervisor or master and implement fatigue risk controls as required.
3	Monitor for signs of fatigue; no additional risk controls required.

APPENDIX 2

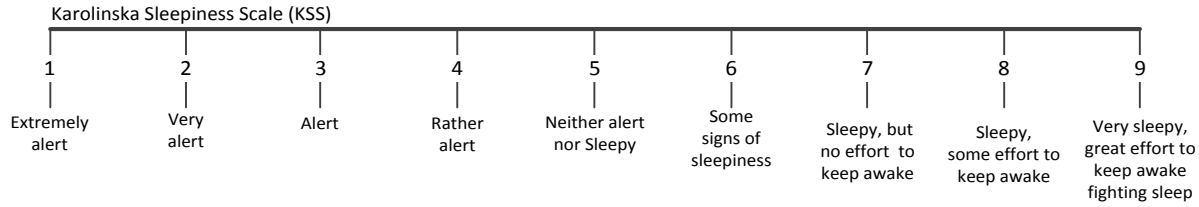
EXAMPLE OF A FATIGUE EVENT REPORT INFORMATION

This appendix provides recommended information that can be included in fatigue event reporting. Companies may decide to utilize parts of this information within their current incident reporting system.

Time of event (When did it happen?)	Time of event:
	Hours from report time to when fatigue occurred:
Describe event (What happened?)	Describe event:

Describe how you felt (or what you observed):

Please circle how you felt when the event occurred:



Please mark the line below with an 'X' at the point that indicates how you felt

Alert----------Drowsy

Relevant Information

Fatigue prior to starting work?	Yes/No	How long had you been awake when the event happened?	hours	mins
Fatigue during work?	Yes/No	How much sleep did you have in the 24 hours before the event?	hours	mins
Disrupted sleep?	Yes/No	How much sleep did you have in the 72 hours before the event?	hours	mins

Suggestive corrected actions	
What did you do?	Actions taken to manage or reduce fatigue (e.g. nap, breaks)
What could be done?	Suggested corrective actions