



## SEAFARER FATIGUE: THE CARDIFF RESEARCH PROGRAMME

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**The views expressed in the report are those of the authors and should not be taken to reflect the official position of the sponsors.**

## SUMMARY

### Main messages

- Prior to this research programme there was very little evidence based research concerning fatigue at sea (see (Allen, Wadsworth, & Smith, Submitted), and section 3).
- The potential for fatigue at sea is high due to a range of factors, many unique to the marine environment.
- To understand fatigue at sea negative risk factors must be considered in combination rather than alone. This reflects the reality of the seafarers' working experience (see (McNamara, Allen, Wadsworth, Wellens, & Smith, Submitted), and section 5.1.2).
- Fatigue increases most significantly during the first week of tour, perhaps reflecting adaptation, a ceiling effect, or a combination of these possibilities (see (Wadsworth, Allen, Wellens, McNamara, & Smith, 2006), and section 5.2).
- Recovery from fatigue after a tour of duty on average does not occur until the second week of leave (see (Wadsworth, Allen, Wellens, McNamara, & Smith, 2006), and section 5.2).
- Fatigue can be addressed at three levels: legislation, company policy and personal awareness/management. Success will only be achieved if all three are co-operatively involved.
- Present reporting systems are inadequately designed to record factors relevant to fatigue (see (Allen, Wadsworth, & Smith, 2006), and section 6.3).
- Excessive working hours are a problem in the seafaring industry, hidden by the fact that a concerning number of crew falsify audited records (see (Allen, Wadsworth, & Smith, 2006), and section 6.3).
- Those who at least occasionally under-record their working hours were found to report higher fatigue (see (Allen, Wadsworth, & Smith, 2006), and section 6.3).
- Fatigue was consistently associated with poor quality sleep, negative environmental factors, high job demands and high stress. Other important factors included frequent port turn-arounds, physical work hazards, working more than 12 hours a day, low job support and finding the switch to port work fatiguing (see (McNamara, Allen, Wadsworth, Wellens, & Smith, Submitted), and section 5.1.2).
- In the diary study more frequent port calls were associated with greater fatigue among those on shorter tours, and with lower fatigue among those on longer tours. This difference would appear to reflect ship type (see (Wadsworth, Allen, Wellens, McNamara, & Smith, 2006), and section 5.2).
- Mini-bulkers arguably represent a worst case scenario in terms of a ship environment conducive to fatigue, as evidenced by subjective and objective testing. The combination of negative factors on this ship type include: frequent port turn-arounds, short port stays, changing cargoes, only two watchkeepers (in many cases) and long periods of pilotage (see section 5.3.2).

- Consequences of fatigue have been shown not only in terms of accident contribution but self-reported physical and mental health outcomes (see (Wadsworth, Allen, McNamara, Wellens, & Smith, Submitted; Wellens, McNamara, Allen, & Smith, 2005), and section 5.1.4).

## EXECUTIVE SUMMARY

### **Background**

Global concern with the extent of seafarer fatigue and its potential environmental cost is widely evident across the shipping industry. Maritime regulators, ship owners, trade unions and P & I clubs are all alert to the fact that with certain ship types a combination of minimal manning, sequences of rapid port turnarounds, adverse weather conditions and high levels of traffic may find seafarers working long hours and with insufficient recuperative rest. In these circumstances fatigue and reduced performance may lead to environmental damage, ill-health and reduced life-span among highly skilled seafarers who are in increasingly short supply. A long history of research into working hours and conditions in manufacturing as well as road transport and civil aviation industries has no parallel in commercial shipping. There are huge potential consequences of fatigue at sea in terms of both ship operations (accidents, collision risk, poorer performance, economic cost and environmental damage) and the individual seafarer (injury, poor health and well-being,). Not only has there been relatively little research on seafarers' fatigue but what there has been has been largely focused on specific jobs (e.g. watchkeeping), specific sectors (e.g. the short sea sector) and specific outcomes (e.g. accidents). This reflects general trends in fatigue research where the emphasis has often been on specific groups of workers (e.g. shiftworkers) and on safety rather than quality of working life (a crucial part of current definitions of occupational health).

### **Aims and objectives of the present research programme**

Given the absence of extensive research on seafarers' fatigue we have carried out a research programme aimed at providing a knowledge base to:

- 1) *Predict worst case scenarios for fatigue, health and injury*
- 2) *Develop best practice recommendations appropriate to ship type and trade*
- 3) *Produce advice packages for seafarers, regulators and policy makers*

These aims have been met using several different methodologies. More specific aims set at the start of the project, and the ways in which they have been met, are summarised in Table 23 below. Other aims and objectives developed as the research progressed are separately described within the context of the report.

### **The concept of fatigue**

Underlying this report and the research programme is a conceptualisation of fatigue as a *process*. This process begins with risk factors for fatigue (i.e. work characteristics and conditions associated with fatigue), moves on to subjective perceptions of fatigue (i.e. how and when an individual experiences and reports fatigue), and concludes with the consequences of fatigue both in the short (symptoms of fatigue such as loss of concentration; poor performance) and longer term (e.g. ill health). This process approach has been suggested elsewhere in relation to work characteristics, fatigue and ill health, and is analogous to the approach to stress widely used in studies of the general working population. The work described here approached fatigue in this way.

Both subjective and objective measures of fatigue were used, and these measures have been compared. In terms of health, however, only subjective measures were possible as seafarers identified at their medicals as having a chronic illness or condition cannot continue to work at sea. The World Health Organisation (WHO) defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO). The measures used in this research fit within this definition of health, and in this report the term “health” has been used in this WHO defined sense. Furthermore, this focus on perceived ill health and well being is supported by clear findings showing that reduced psychological well being can increase the risk of some physical illness.

## **Methods**

The aims of the programme were achieved through surveys, analysis of existing databases and field research. The methods involved:

- A review of the literature
- A questionnaire survey of working and rest hours, physical and mental health
- Physiological assays assessing fatigue
- Instrument recordings of sleep, ship motion, and noise
- Self-report diaries recording sleep quality and work patterns
- Objective assessments and subjective ratings of mental functioning
- Pre- and post-tour assessments
- Analysis of accident and injury data

## **Results**

### **The literature review**

A review of the international literature showed that research is increasingly revealing fatigue to be a significant problem in the seafaring industry. Present reporting systems, however, are often not designed to record this factor. Evidence shows seafarer shift and working patterns are often conducive to fatigue with two man watches and excessive working hours areas of particular concern. Research also suggests that the impact of fatigue on seafarers may be seen in terms of health, psychosocial consequences, impaired cognition and increased risk of accidents.

### **The survey**

In total, 1856 seafarers took part in the survey. Most of the respondents were deck (49%) or engineering (36%) officers. Just over 40% (41%) worked on ferries, 25% on offshore support, supply or standby vessels, and 19% on tankers. Two thirds (67%) of the respondents worked on UK flagged vessels. Results from the survey showed that fatigue was consistently associated with poor sleep quality, negative environmental factors, high job demands and high stress. Other factors found to be important included: frequent port visits, physical work hazards, working more than 12 hours a day, low job support and finding the switch to port work fatiguing. The short-term consequences of

fatigue (reported symptoms of fatigue, and the perception of risk to personal safety) were also associated with a similar range of factors. Those most at risk of high levels of fatigue and associated consequences were those who reported the greatest number of fatigue-inducing factors. It is therefore important to consider the combined impact of negative factors rather than considering them alone.

An association between perceived fatigue, self-reported health status and cognitive function was also shown. This association was independent of work characteristics shown to be risk factors for fatigue. Subjective fatigue may therefore be a factor which impacts on health independent of other risk factors.

A high proportion of the sample reported having been involved in a collision with another vessel (most of these incidents were between two moving vessels), or with another object (in most cases the harbour side). Nearly half of the sample considered fatigue to be a key factor in reducing collision awareness. One in four watch-keepers (particularly those on longer watches) reported having fallen asleep on watch. Almost all watch-keepers were required to multi-task while on watch, and just under half of these found this to be problematic. Those who did find multi-tasking problematic reported higher fatigue levels, and were more likely to have fallen asleep while on watch. A smaller but significant number (17%) were concerned about potential collisions and were again found to have higher fatigue levels and be more likely to have fallen asleep on watch. By far the most common suggestion for helping provide more effective and alert watch-keeping was to increase manning. This was followed by shorter watches and reduced paperwork.

The research compared fatigue in seafarers with other working groups. Workers from offshore oil installations (N=388) were found to have higher levels of fatigue and poorer health than the seafaring sample. Factors associated with fatigue, however, were found to be very similar to those associated with fatigue among seafarers. The seafaring sample was found to have similar levels of general fatigue to an onshore working sample (N=99), but higher levels of fatigue at work. Comparing seafarers with a road haulage sample (N=80) suggested change of operation may be a fatigue-inducing factor irrespective of transport sector. The seafarers were also compared with a sample of fishermen. Considerable recruitment difficulties, however, enabled only a small sample to be surveyed (N=81), severely restricting the level of generalisation possible concerning the approximately 12,500 fishermen currently working in the UK. In terms of the small sample which was accessed, most reported working on smaller vessels with an average crew of 3.04 (sd=1.74, range 1-11). Many reported that they had worked to the point of collapse and fallen asleep at the wheel and over half of the sample believed that their personal safety was at risk because of fatigue. Comparisons were also made across different sectors of the shipping industry. Seafarers in the short sea and coastal sample were found to report higher levels of fatigue than those from an offshore oil support sample. This may potentially be explained in terms of type of vessel and frequency of port turn-around.

## **Diary studies**

In a diary study of seafarers over a complete tour-leave cycle, 203 respondents completed tour diaries and 197 leave diaries (182 completed both). Fatigue was found to increase most significantly in the first week of tour. Evidence suggested recovery from tour does not typically occur until the second week of leave. In this study more frequent port calls were associated with greater fatigue among those on shorter tours, and with lower fatigue among those on longer tours. This difference would appear to reflect ship type, as those on shorter tours mainly worked on ferries, while those on longer tours mainly worked on supply, support and container or tanker vessels. Of methodological significance, the diary study found fatigue on waking to be a more sensitive measure of fatigue than a measurement taken before bed.

## **Objective testing onboard**

Onboard performance testing showed that fatigue risk factors such as noise, night work and days into tour have an impact on alertness and performance. Crew on a mini-bulker were found to more fatigued than crew on other vessels in terms of both subjective and objective measures.

## **Prevention and management of fatigue**

The project evaluated the efficacy of methods aimed at preventing or managing fatigue. The results showed that the impact and effectiveness of ILO 180 and the EU working time directive appear to be undermined by widespread under recording of working hours. Evidence suggests large numbers of seafarers are working hours in excess of those allowed by current legislation and that under recording of working hours is associated with higher levels of fatigue. Fatigue guidelines produced by IMO put excessive emphasis on the responsibility of individual crew members to manage fatigue without acknowledging the critical role of corporate and legislative bodies. Fatigue can only be addressed if all levels of the seafaring industry are co-operatively involved and accountable.

## **Conclusions**

The overall aim of the present programme of research was to provide a knowledge base on seafarers' fatigue. This has been achieved using a range of methodologies and by studying samples from different sectors of the British maritime industry. The results show that the potential for fatigue at sea is high due to seafarers' exposure to a large number of recognisable risk factors, both operational (e.g. port frequency), organisational (e.g. job support), and environmental (e.g. physical hazards). Our results show, however, that it is the combined effect of these risk factors that is most strongly associated with fatigue and its both short and long term consequences (fatigue symptoms, personal risk and reduced health and well-being). The most at risk groups are those exposed to the greatest number of these factors which could be identified using an audit styled approach. We have also shown that perceived fatigue is an additional risk factor for negative outcomes and this should also

be included in any audit process. A taxonomic approach to fatigue should be used and measures of the frequency and intensity of different types of fatigue (e.g. acute versus chronic; physical versus mental fatigue) obtained. Appropriate tools for this have been developed and the use of measures of risk factors for fatigue and perceived fatigue will allow future associations with outcomes (e.g. accidents and injuries; health status) to be assessed. It is also important to consider personal characteristics of the seafarer to determine the extent to which these influence susceptibility to fatigue.

One of the problems with measuring fatigue is that there is no “gold standard” that has been used in large populations and would allow bench-marking across jobs. It is difficult, therefore, to provide global estimates of the prevalence of fatigue in seafarers and to compare these levels with onshore groups. Indeed, where diversity is one of the defining features of the seafarer population such global estimates can prove misleading, not accounting for important differences in terms of ship operation, flag of registration and crew nationality. All that can be concluded is that highly fatigued seafarers are undoubtedly working in the industry where a combination of risk factors are found together. We have investigated a ship of a type thought to be associated with excessive fatigue (mini-bulker) and shown that higher subjective reports of fatigue are associated with objective performance deficits. Indeed, our performance measures have also been shown to be sensitive to risk factors for fatigue (e.g. working at night; noise) suggesting fatigue cannot be considered a purely subjective phenomenon. This is also confirmed by associations between fatigue-inducing conditions and accidents. Our research has also shown that the consequences of fatigue are not only felt in terms of impaired performance and reduced safety but decreased well-being and increased risk of mental health problems, also known to be risk factors for future chronic disease. Such effects are not restricted to seafarers and were found to be even greater in installation workers. Part of these effects may reflect the general problems associated with being at sea and in the workplace 24 hours a day, 7 days a week for several weeks at a time and away from home. Our sample has largely come from the “better end” of the industry and the prevalence and consequences of seafarers’ fatigue may, to some extent, be underestimated here. Further research at an international level is needed to investigate this view. Similarly, it is important to study those just starting at sea to determine whether fatigue is an important factor in the high attrition seen with this group. Fatigue may also be important in early retirement from seafaring and this issue could be addressed using the methods employed here.

Given the diversity of activities undertaken in the maritime sector, and the different profiles of fatigue risk factors in different work groups, it is clear that a range of strategies will be needed to prevent or manage fatigue. Having evaluated current working time directives and a fatigue guidance publication from IMO, existing approaches seem largely inadequate. Improvement of these approaches is clearly one strategy that could reduce the problem although an awareness campaign approach, as proved successful in other transport sectors, may also have value. Similarly, fatigue management programmes have been developed in other industries and such approaches could form part of a package for dealing with fatigue at sea. Indeed, the general absence of fatigue awareness and management training in the



























































































































































