Safety Critical Offshore Workers in the UK Oil & Gas Sector: Hours, Shifts & Schedules

March 2016

Stewart Research
4 Albany Quadrant
Springboig
Glasgow G32 0HL

Scottish Centre for Employment Research (SCER)
Department of Human Resource Management
University of Strathclyde

Contact: Dr Robert Stewart
Tel: 0141-774-3910/07901841087
E-mail: robert.stewart9911@gmail.com

CONTENTS

INTRODUCTION

This report was commissioned by the Offshore Co-ordinating Group (OCG) and provides a review of the existing research evidence on the impact of long hours, shift working and work scheduling for offshore workers in the UK oil and gas industry. Shift working and long hours have been endemic features of the industry since the 1970s. Offshore installations operate on a 24-hour cycle of 'alternating' on/off shift schedules and extended hours: invariably conducted in remote, hostile physical environments away from networks of family, friends and onshore supports; a system that tries to balance the need for safety with the economic demands for production (Ross 2009). Offshore workers face 'unique' demands in the types of roles they undertake in 'hostile' environments. Offshore working exposes workers to 'hazard', 'risk' and a range of demands that probably outweigh most comparable shift systems experienced 'onshore' by others working in safety critical roles: such as those in protective services and healthcare, aviation, rail and other energy sectors[1].

Offshore work is invariably physical, repetitive and monotonous (Ross 2009): it generates a range of physical, temporal and psychosocial stressors (e.g. heavy work schedules, proximity of workers and lack of privacy, and working outdoors or in confined spaces for extended periods of time) where individual fatigue[2] and other health issues increase the risk of accidents and hazardous events. Our understanding is that there is a developing trend among offshore operators who are moving away from previously established offshore duty schedules of two weeks on/off (i.e. 2/2) and two weeks offshore followed by three weeks onshore (i.e. 2/3) towards three weeks on/off schedules (i.e. 3/3). This report draws on current research evidence from the UK and international literature on offshore occupational health and safety and well-being in general, and on the available comparative literature from other safety critical industries (particularly healthcare), to look at this proposed move in more detail in terms of the implications for fatigue, risk and safety offshore.

---

[1]In 2009 using Labour Force Survey (LFS) data, about 1 in 5 UK employees worked in professions using shift work (18%). The most common shift work professions typically covered: *transport and communications; manufacturing*; *public administration education and health*; *distribution, hotels and restaurants*; *banking*; *construction* and *other services*. These categories cover those working in *managerial/professional* occupations (e.g. executives, computer IT personnel), and those in *protective* (e.g. emergency medical services workers, police, and firefighters); and *healthcare* (residents and on-call physicians and nurses) services. The most common form of UK shift work pattern reported by those engaging in shift work was the *two shift* system. This typically comprised of two shifts of eight hours in duration which are usually alternated weekly or over longer intervals (ONS 2011).

[2] Fatigue has long been associated with long shifts and severe fatigue at night has been linked with disasterous events such as Chernobyl, Three-Mile Island, Bhopal and the Exon Valdez (Miller et al 2008). Fatigue has been listed as a major contributory cause of error and accidents. For example, pilot fatigue contributes to between 15-20% of fatal incidents caused by human error and 43% of UK pilots have reported falling asleep involuntarily while on the flight deck (House of Commons Transport Committee 2013). US Military and commercial operations have long recognized the threat of additive fatigue factors in shift work: 12% to 25% of their most severe military mishaps were related to fatigue (Dinges 1995, Caldwell and Caldwell 2005). Many studies have concluded that performance errors increase significantly when continuous working exceeds 12 hours (e.g. Krueger 1991). Prolonged periods of wakefulness produce attention lapses and slower reaction times, which are associated with poor performance (Horne 1978, Bonnet and Arnand 2003). It is estimated that sleep-deprived personnel lose approximately 25% to 30% of their ability to perform useful mental work with each 24-hour period of sleep loss (Angus et al 1995, Belenky et al 1994). A study on the impact of fatigue on American F-117 pilots revealed that 27-33 hours of sleep deprivation (i.e. one night of sleep loss) degrade basic piloting skills by more than 40% below normal (Caldwell et al 2003).

1.1 The UK Offshore Sector

In 2014, the UK offshore oil and gas industry comprised around 107 oil and gas plus 181 gas producing installations, located on 383 producing fields with a supporting infrastructure of 14,000 km of pipelines connecting installations to beach terminals. The industry has operated since the early 1970s with a forecast to continue operating to 2030 and beyond. The industry involves both basic extraction and exploration (using mobile offshore drilling units - MODUs) whose operation varies year to year, from ten to thirty units) activities. The main characteristics of the industry are (HSE 2014):

- The majority of offshore activity is in the North Sea, with smaller operations in the Irish Sea and West of Shetland. In 2014, around 50 new field developments were planned across all sectors including 8 West of Shetland. Unlike North Sea operations, in West of Shetland, the weather and sea conditions, distances from shore and the absence of a readily available onshore infrastructure are particularly challenging for operators.

- In 2015 operators employed around 28,000 'core' workers[3] in offshore work and many more are employed as contractors and in supporting roles and activities. Offshore workers only accounted for 45% of the total offshore workforce. Around 64,000 people travelled offshore in 2015 (Oil and Gas UK 2015)

- The majority of those working offshore worked for a single operator and around 50% worked in the central North Sea area.

- Oil and gas production meets around 50% of the total primary energy needs of the UK and contributes around £50 billion annually to the balance of payments. Its UK supply chain recorded revenues of £27 billion in 2011. Production has declined from 1999 onwards as the most easily accessed fields are exhausted. New fields tend to be in deeper waters and under higher temperatures and pressures, further challenging operators in more hostile working environments.

- Whilst there is significant investment in new infrastructure, much of the existing infrastructure is ageing and has been exposed to a harsh environment and heavy usage. In 2014, it was estimated that approximately 50% of offshore platforms are beyond their original design life. Much work is required to ensure that corrosion and other factors have not affected the structural strength of pipelines, installations or the integrity of topside plant and equipment (HSE 2014).

- In terms of accidents and injury there have been a total of 5 fatalities offshore since 2010/2011. In 2014/2015 there were 16 'specified'[4] injuries (a rate of 48 per 100,000 workers), a decline over the preceding three years, and 125 'over 7-day' injuries (a rate of 425 per 100,000 workers), with signs of a possible increase in the last three years (HSE 2015).

[3] Defined as those who worked more than 100 nights offshore.

[4] 'specified injury' means any injury or condition specified in regulation 4(1)(a) to (h) of the Health and Safety at Work Act (1974).

1.2 Offshore Workforce Characteristics

Annual data is available on the demographics of the offshore workforce from Oil & Gas UK. This allows the monitoring of workforce changes to be tracked over time and recruitment/ retention issues to be identified. The main characteristics of the workforce in 2015 were[5]:

- Offshore workers are overwhelmingly male (87%). Only 4% of the total offshore workforce and 3% of the total 'core' workforce respectively are female. Female personnel are mainly in catering and administration roles. This has been the prevailing gender trend in the industry since the mid-70s.

- The average age of offshore workers is 41 years. This figure has remained relatively stable over the past decade.

- In the mid-90's around 12% of offshore workers were over 50 years of age[6] (Parkes and Clark 1997). The current 50+ age group looks reasonably consistent with this figure and with wider UK data on shift workers (13% in 2009 according to ONS 2011).[7] Most new recruits are in age groups under 50 years and younger workers were particularly prominent in drilling and well teams, and services.

- Most offshore personnel are of British nationality (84%) and just over a quarter of the total offshore workforce lived in Aberdeen and Aberdeenshire (27%).

1.3 Aims & Objectives

The overarching aim of this report is to provide an independent assessment of the existing literature on working offshore and the impact this has on health and wellbeing.

The research had a number of specific aims to:

- Review the safety criticality of offshore working and current Health & Safety Executive (HSE) guidance on long hours, shift working and condensed working schedules on worker health and wellbeing for offshore workers.
- Review existing knowledge on the impact of long hours, shift working and condensed working schedules on worker health and wellbeing.
- Provide a concise summary of the implications of broader evidence for offshore workers.

Where possible we draw on comparisons between offshore personnel and those in other safety critical shift working populations. Although it is not possible to define an appropriate compactor occupational group or sector for offshore workers, there are a number of general comparisons we can make from studies looking at safety critical populations, across occupations and settings.

[5] Source - Oil and Gas UK (2015). This applies to the 'core' workforce though the demographic profile of the contractor workforce looks very similar.

[6] After which personnel are required to have annual medical examinations compared to bi and tri-annual examinations for younger age groups.

[7] Oil and Gas industry annual workforce demographic reports do not provide the raw data to allow age group comparisons to be conducted.

1.4 Structure of the report

In Chapter 2 we look at HSE regulation and guidance on shift working offshore before looking at the evidence on the health consequences of working in these settings in Chapter 3 and the potential implications of moving towards more 3/3 schedules. In Chapter 4, we provide a brief summary of the main conclusions we can draw on this working schedule in the UK Offshore industry.

2. REGULATION AND GUIDANCE ON SHIFTS & HOURS

2.1 Introduction

In the chapter we categorise offshore personnel as safety critical workers and outline the regulatory requirements for ensuring levels of health and safety offshore. This provides the legislative and operational context for describing the hours and shifts worked by offshore personnel within the current guidelines set by the UK Health and Safety Executive (HSE). The latter usefully identity a range of 'hazards' for offshore workers and these are identified at the end of this Chapter.

2.2 Offshore Regulation & Safety Critical Workers

Offshore operators are regulated by the Energy Division (ED) of HSE. This body is responsible for regulating the risks to health and safety arising from work activity in the offshore oil and gas industry on the UK Continental Shelf (UKCS)[8]. HSE and the Department of Energy and Climate Change (DECC) work in partnership in the Offshore Safety Directive Regulator (OSDR) to act as the body responsible for implementing the requirements of the EU's Offshore Directive on the safety of offshore oil and gas operations. The objective of this Directive was to reduce as far as possible the occurrence of major accidents and to limit their consequences. It was adopted in June 2013 and contains requirements relating to licensing, environmental protection, emergency response and liability, in addition to safety. Although the Directive is broadly based on the UK's current offshore safety regime, HSE and DECC's legislation has been updated to fully implement the Directive. This includes changes to existing legislation as well as introducing new requirements. HSE have implemented the majority of the health and safety requirements in the Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015 which came into force on 19 July 2015. DECC have also introduced new regulations to implement environmental and licensing requirements.

Almost by definition *offshore safety critical* elements include all those parts of an installation and its components (e.g. Subsea, Topside, Ancillary, Distribution, or even IT programmes) where failure could cause or contribute to a major accident. These could include Blowout Preventers (BOPs), Emergency Shutdown (ESD), Overpressure Protection, Flare & Blowdown, Emergency Power and Hydrocarbon Containment, among others.

Like all UK employers, offshore operators have a duty in relation to the offshore workforce under the Health and Safety at Work Act (1974) (HSAWA) to ensure a safe system of work. It is implicit in this duty that the medical fitness of employees is a critical component of any safe working system, to the extent that the effects of a medical condition are foreseeable. Not only do employers have duties towards their employees but under Section 3 of the HSAWA they also have a duty to ensure that the safety of third parties is not compromised. In the current context, therefore, the employer needs take into account the individual employee's fitness both in respect of those activities where an employee's fitness may be likely to affect their own health and safety and those where it may affect others' health and safety. In some activities such as offshore

[8] Risks are typically defined in terms of those which are operational (e.g. risk of explosion, fire, structural failure, shut-down, reduced productivity) resulting from human error and impaired performance, and *risk to the physical and psychological well-being of individual offshore workers* (e.g. injury, illness, sleep disturbance, anxiety) (Parkes 2010).

environments the consequences of adverse events may be serious and the term "*Safety Critical Work*" has been used. Safety critical work (or roles) were defined in the Faculty of Occupational Medicine's *"Guidance on alcohol and drug misuse in the workplace" 2006* as: *"those involving activities where, because of risks to the individuals concerned or to others, the employees need to have full, unimpaired control of their physical and/or mental capabilities".* A Safety Critical Worker (SCW) is typically defined as: *"Where the ill health of an individual may compromise their ability to undertake a task defined as safety critical, thereby posing a significant risk to the health and safety of others"* (Occupational Medicine 2012). Consequently, a risk assessment of any task or activity should identify what aspects of the working role has a safety critical dimension: and whether in the event of worker incapacity or impairment to their physical and mental capabilities, this would be likely to result in a significant risk of harm to the individual worker performing the task or to others i.e. third parties. In this sense, offshore workers (both 'core' and contractors) can be looked upon as SCW's in much the same way as others in industries such as construction, emergency services and the wider energy sector, occupy SCW roles.

The offshore environment places significant physical and psychological demands on workers who undergo the regular working lifestyle of defined and sustained periods of intense work (i.e. shifts and 'tours' offshore) in otherwise 'hostile' settings. The demands and risks of their working environment mean that it is mandatory for all offshore personnel to undertake a medical examination conducted by a certified doctor at least every two years to maintain their certificate or 'fitness' to work. In order to ensure health standards and mitigate instances of poor health, all personnel are required to satisfy a set of minimum criteria on a range of medical measures[9]. This ensures that offshore workers are medically 'fit' and constitute a reasonably healthy workforce to defined standards for offshore environments. This reduces individual medical and operational risks, optimises workforce production and individual performance, and minimises absenteeism through ill-health. This factor also makes offshore workers unlike many other shift work populations.

2.3 Safety: Hours & Shifts

Many UK continuous work time limits have been mandated by law: with long-haul truck driver and commercial carrier pilot night time hour limits set at 10 hours/day and daily at 11 hours; and railroad engineers' limits set at 12 hours/day. Most frontline healthcare professionals also now work 12 hour shifts as do those in Nuclear power plants. Unlike transport personnel, however, there are no additional legal limits on the working time of offshore personnel outwith those set by the EU Working Time Directive.

Offshore operators have been required to implement legal working time limits within the context of the European Working Time Directive. The UK legal framework is the 'Working Time Regulations, 1998' (WTR)[10], and an amended version of this (the 'Horizontal Amending Directive') came into force in August 2003, extending the WTR to 'other work at

[9] Medical assessments include: Body Mass Index (BMI), Vision, Pulse and Blood Pressure, Lung Capacity and Urinalysis. Increasingly, operators also use Functional Capacity Evaluations (FCEs) to assess physical fitness (i.e. strength, stamina, aerobic fitness and role-specific task simulation (Doig 2007).

[10] The WTR offshore has been subject to a number of legal challenges regarding its coverage by Employment Tribunals (ETs) and notably whether shore breaks satisfied the annual leave allowance set by the WTR. Currently, a work pattern of 13 two-week tours per year, interspersed with two-week leave periods, continues to be lawful within the framework of the current WTR.

sea' including offshore work[11]. The WTR introduced a maximum working time limit of 48 hours per week averaged over a defined reference period (offshore this is 52 weeks). The Regulations, however, allow this 48 hour maximum to be extended if employees sign a voluntary opt-out agreement[12].

A distinguishing characteristic that separates the UK offshore sector from other employment sectors is the nature of their shift working arrangements. Typically these involve an uninterrupted duty period (or tour) of at least 14 consecutive shifts of 12 hours each followed by 14 days of rest resulting in an equal ratio of work and rest[13]. This is usually referred to as a two week tour (i.e. 2/2). Tours may be worked as consecutive days, consecutive nights, or a combination of the two with a mid-tour 'rollover' shift (i.e. typically 7 days on nightshift followed by 7 days of dayshift, or vice versa (Ross 2009). The 14 consecutive work periods of 12 hours is described by HSE as *unusually long for a high risk industry* and has arisen because of limitations to the numbers of employees that can be accommodated on offshore installations. To prevent fatigue and optimise safety, HSE (2008, 2012) recommend that shifts last no more than 12 hours but that extenuating circumstances (e.g. emergencies) mean that longer hours can be worked so long as this practice is not 'normal', that a risk assessment is conducted and that additional breaks are provided to maintain worker 'alertness'. There is also a significant overall risk reduction provided by having two workers offshore per post rather than the three that would be required if eight hour shifts were worked. Shift working patterns and tour lengths are directly under management control and subject to risk assessment, and a risk based decision process that reduces these issues so far as is reasonably practicable.

Limitations on a 12 hour shift is perfectly consistent with the wider research evidence in other safety critical settings in healthcare, transport and military environments that associate these extended shifts with the greater likelihood of fatigue and adverse events. Reviews of shift studies among nursing and healthcare staff highlight that while 12 hour shifts can have performance benefits (for the organisation), most studies are negative and link increased shift fatigue to increased adverse outcomes for staff and patients (e.g. quality of care) which jeopardise safety (Ball et al 2015). Geiger Brown et al (2012), for example, recommend that healthcare staff work no longer than 12hours/day and other calls have been made in the aviation sector to restrict this even further to 10 hours per day (House of Commons Transport Committee 2013).

HSE also stipulate that for every block of 5-7 days (i.e. a working week) involving 12 hour shifts, there should be one rest and recovery day. Although the HSE guidelines have an upper ceiling maximum of 84 working hours per week, they expect 72 hours (i.e. 6 days of 12 hour shifts) to be a more realistic figure for offshore shift work.[14] However, some feel that even this figure is relatively high within safety-critical industries such as the offshore, rail, aviation and nuclear sectors (e.g. Barnes 1998, Burgess et al 2002,

[11] For a detailed outline of the WTR and their coverage, application and exceptions see TUC (2013) *https://www.tuc.org.**uk**/**work**place-issues/**working**_time.cfm*

[12] The EU WTR also includes the right to 11 hours continuous rest in each 24 hour period, to 24 hours rest over each 7-day period and to 5.6 weeks paid annual leave (inclusive of public holidays) capped at 28 days (i.e. 5 x 5.6 days). Where it is difficult for an employer to allow the required rest periods, an equivalent period of rest, taken at some other time, must be provided. For offshore workers these compensatory rest periods fall within the shore break.

[13] 12 hour shifts can be extended to 14 hours but beyond this a risk assessment must be conducted to ensure safe working.

[14] This means that a 2/2 tour involves active duty between a minimum of 144 hours and a maximum of 168 hours per tour with alternating rest periods. A 3/3 tour increases these duty hours thresholds by a full third to between 216 and 252 hours per tour. If we take the midpoint as a proxy average this means that on a 2/2 tour of 78 hours per week, personnel may work between 50-62% hours above the normal statutory 48 hour WTR limit.

Drake et al 2004). Consequently, HSE advises supervisors to evaluate the work rotas of those personnel nearing the end of their weekly shift, especially where machinery or high hazard working is evident. This advice is consistent with Parkes (2010) and Ross (2009).

Nevertheless, the largely anodyne picture of offshore hours may not be as non-problematic as it first appears from HSE guidelines. Although working 'hours offshore' are logged on UK Oil & Gas *Vanguard Database*, there is a dearth of publically available disaggregated data on hours, or data that could be extrapolated from national UK surveys[15]. Parkes (2010), highlights that overtime is typically confined to 'day' workers in construction/ deck roles who may work over the daily 14 hour limit. Hours vary across occupations. Parkes and Clark (1997) report that 48% of personnel working in construction and/or deck work self-reported 94 hours/week plus, compared to only 13.5% of catering personnel. Similarly, Woolfson et al (1996) 'claimed' that while the average annual hours worked in British manufacturing were in the 1680-1800 hour band, an offshore contract worker (excluding travel time) worked 2184 hours per annum, "400-500 hours of additional risk exposure" (p.359). Parkes (2010) also reports that those most likely to work long hours offshore are senior managers, particularly offshore installation managers (OIMs), who frequently choose to work much longer than a normal 12-hr shift: 64% of senior managers offshore reported working more than 100 hours per week, and a further 26% reported 94-100 hours per week. All of this data (though some of it relatively 'dated') presents an obvious contrast with HSE guidelines.

HSE states that accidents and 'near miss' investigations usually conclude that human error and operator tiredness has often been found to have played a part. However, incident reports rarely contain information on operator tiredness. The reason may well be that individuals are concerned that to do so may result in some personal blame being attributed. This can result in a *falsely positive picture* of the shift work and fatigue on an installation that can only be corrected by detailed assessment using human factor techniques, for example, a human factors root cause analysis after an incident.

HSE has a well-defined and articulated Safety Management Model (SMM) for the offshore sector that is applied by operators. This covers:

- **Policy** (e.g. shift and work schedules; objectives for safety, alertness and performance; allowing for circadian rhythm adjustments).
- **Organising** (e.g. provision of risk control measures and procedures for shift work, mitigation of fatigue, linkage with other known risks, advice on fatigue, monitoring performance, sleep/rest strategies and the design of the working environment to minimise risk).
- **Planning & Implementation** (i.e. operational and workforce-level measures to avoid risk).
- **Measuring Performance** (i.e. on shift work including measures for assessing individual fatigue and hours).
- **Auditing and Performance Review**.

There is a clear and unambiguous recognition in HSE guidance on shift work and fatigue[16] that these issues are invariably related to staffing levels and workload on one

[15] Labour Force Survey (LFS) and Annual Survey of Hours and Earnings (ASHE).

[16] A significant number of shift workers may experience severe enough consequences from misaligned sleep-wake patterns to carry the diagnosis of Shift Work Sleep Disorder (SWSD). The *International Classification of Sleep*

hand and occupational stress on the other. Long working hours and excessive overtime are indicators that staffing levels are too low and both can be used as effective means of identifying and tracking low staffing levels or down-staffing problems. Similarly long working hours and lack of sleep are widely recognised as precursors and causal factors in occupational stress and so monitoring and control of working hours and fatigue can reduce or prevent subsequent problems with work related stress. HSE currently lists a number of known structural 'working' hazards associated with specific aspects of offshore shift schedules. These are:

- Pre-6 am shift *early starts*.
- *Overtime* (the 12 hour + shift).
- Off-duty *call outs*.
- *Extended offshore duty* without breaks.
- Long periods of *task attention*.
- No personnel *back-up cover* for 'no-shows'.
- Tasks combining *low-error tolerance* with high consequences.
- Long *travel times* prior to going offshore combined with starting shifts on arrival.

In this list, HSE identifies two particular task-related offshore 'fatigue hazards'. These are:

- Tasks requiring high *attention and/or vigilance* (e.g. watch keeping, monitoring).
- Tasks with high *physical demands*.

As we shall see in Chapter 3, some of these factors such as overtime, extended duty and tasks with heavy physical demands have also featured in research on offshore workers.

Woolfson et al (1996), argued that EU WTR limits were effectively watered down and smothered by both UK Government and offshore operators to minimise costs. Recurring problems are not just the opt-out that was negotiated from the 48 hour limit set by the EU WTR but its widespread *ignorance among workers*, potential vulnerability to *employer abuse* and concerns about *enforcement*. In this context, it should also be apparent that there is some uncertainty about the ongoing practical impact that any further legal changes will have on work/leave patterns in the UK offshore sector.

Disorders (ICSD) classifies SWSD as one of the dyssomnia, disorders with symptoms of either excessive sleepiness or insomnia (American Academy 2005). All SWSD patients will present one of these two symptoms (often both) as the primary complaint. Estimating the prevalence of SWSD is difficult because of a number of factors, including a general lack of awareness of the disorder, the wide variety of terms used to describe SWSD (e.g. night shift, irregular hours, and transient excessive sleepiness), and different definitions of 'shift work'. One study of shift workers showed that 25% of those who worked night or rotating shifts met the criteria for SWSD (Ohhayon et al 2002). People with SWSD experience attempts to sleep during the daytime (when circadian wake propensity is high) that are shortened/ fragmented. The lack of restorative sleep significantly increases the sleep drive during waking hours, such as during the work shift, which leads to accidents and also poorer control of chronic diseases, such as hypertension and diabetes (Scott and La Dou 1999, Costa 2003). Closely related to the ICSD criteria for SWSD are the criteria for the diagnosis of Circadian Rhythm Sleep Disorder, shift work type, in the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (*DSM-IV*). The *DSM-IV* criteria require that insomnia occurs during the major sleep period or that excessive sleepiness occurs during the major awake period, and that these symptoms are associated with night shift work or frequently changing shift work. In addition, all *DSM-IV* circadian rhythm sleep disorders require a finding of clinically significant distress or impairment in social, occupational, or other important areas of functioning.

3. EVIDENCE: HEALTH & OFFSHORE WORKING PATTERNS

3.1 Introduction

In this Chapter we look at the evidence of problem health issues associated with the working schedules and patterns for offshore workers. While many studies have typically focused on the effect of shift work and its link with fatigue, studies have also assessed a relatively wide variety of health issues arising from working offshore and their link with risk. While recognising that the offshore environment means that the shift patterns of working are unique, parallels with those in other industries can be drawn (e.g. those working in emergency services, in aviation and in the wider energy industries). Where research has been conducted in these latter groups, with parallels in the offshore industry, we highlight this in the text.

3.2 Health Overview

Although offshore SCWs have been actively researched the literature has a number of significant 'gaps' regarding long hours, shifts and evaluating the strengths and weaknesses of different working schedules[17]. Despite this, health and wellbeing issues have strongly featured in studies among UK offshore personnel. Research has focused on a number of topics to the extent that they influence fatigue and other physical and psychological health outcomes for individuals working offshore.

Research has typically focused on the following areas[18]:

- Occupational Stress generated through exposure to physical (e.g. noise, temperatures and outdoor exposure, cramped conditions, heavy workload, etc)[19], temporal (e.g. shift hours and schedule) and/or psychosocial stressors (e.g. social support, supervision, etc)
- Mental Health and Wellbeing.
- Body Mass Index (BMI) and Diet.
- Physical Activity.
- Musculoskeletal Disorders (e.g. back pain and upper limbs).
- Addictive behaviours (i.e. smoking, alcohol and drug abuse).
- Shift Work (i.e. on general health and sleep).
- Working Patterns (e.g. of shifts).

The most extensive area of research has concerned studies looking at the impact of shift work (typically defined as working shifts between 1900 and 0600 hours (e,g, Monk and Folkard 1992) but more broadly looked at as employment in any regular working schedule that extends beyond 'daytime' hours - Gibson-Smith et al 2015), although some studies such as Parkes (2012) also extended their focus to look at broader working patterns. In the former studies, the primary emphasis has largely been on fatigue and the disruption of the circadian rhythm (CR) (i.e. the 24 hour biological process) caused by

---

[17] This is also common in other occupational groups, although collectively the evidence allows inferences (if not generalisablity) to be drawn between different groups of shift workers.

[18]Alongside this there is the issue of individual differences in health, disease and lifestyle which shape people's reactions to these offshore working environments.

[19] These will affect different occupational groups. For example, offshore drill teams, deck crews and maintenance and operations teams will be exposed to severe physical demands.

extended shift schedules. CR disruption has long been known to impair an individual's ability to function: disorientation, confusion, fatigue and insomnia,[20] as personnel adapt, adjust and acclimatise to alternating day-to-night and night-to-day shift schedules. Because of remote offshore locations, unlike many other shift work occupations (e.g. in manufacturing, in plants and in healthcare) where 'shift schedules' largely operate over a relatively short period, in offshore settings these schedules are extended and can cover more than 12 hours a day over a minimum period of between two and three weeks.

The volume of research however, has also meant that researchers have employed a variety of methods to investigate these issues, and consequently some offer more robust, reliable (e.g. larger sample sizes) and generalizable data than others[21]. Studies have been mainly quantitative and there have also been a number of recent reviews of the data in each of the above areas that collate and analyse the results of previous studies by focusing on those that offer more reliable data. This has allowed these reviews to offer and draw more 'secure', robust and reliable conclusions.

Instead of looking at each of the above areas in more detail it is more useful to focus on those concerned with shift work. Issues such as musculoskeletal problems, stress and wellbeing feed into a wider framework based on the pattern of long hours and working shift schedules. For example, 'evening' and 'rotating' shift workers can be more likely to experience higher levels of job strain, greater physical demands, more relationship problems, and higher personal stress levels than day workers. Shift workers in general have greater sleep loss, unhealthy lifestyle behaviours (e.g. smoking, poor diet, alcohol abuse, and lack of exercise), increased stress levels, and a higher incidence of cardiovascular disease, hypertension, and gastrointestinal disorders (e.g. Boggild and Knutsson 1999, Shields 2002). These altered sleep schedules can also lead to marital strain and disruption of social and/or family life; they can also increase the risk for drug or alcohol addiction, because people often self-medicate with these substances to improve sleep and reduce waking episodes (Shiftwork Practices 2004).

3.3 Offshore Shift Work & Working Patterns

There have also been a number of published studies that look at the effects of shift work in the offshore industry. These are largely consistent with the 'fatigue' evidence in wider studies of shift workers. In a comprehensive literature review of the impact of offshore shift work on health, Gibson Smith et al (2015) include two recent systematic reviews by Fossum et al (2013) and Parkes (2012), and three quantitative studies by Waage et al (2009, 2012 and 2013). The main results are summarised below:

- As a general rule, *shift work offshore disrupts normal circadian cycles and is linked with poorer sleep quality, impaired alertness and decreasing task performance* (Fossum et al 2013, Parkes 2012). To date, no evidence has been presented on the decline in performance associated with sleep deprivation in offshore settings.

[20] Similar to the effects of 'jet lag'.

[21] Research among offshore workers has a number of problematic methodological issues. Most studies do not link cause and effect or track individual change. Although research has provided evidence of concern most studies are survey-based using self-report measures (which may not be standardised) and the data may have limited generalisability to changing patterns of offshore settings, sectors, occupational divisions, and among the changing demographic in workforces. The industry also operates across a plethora of international regulatory frameworks whose differences also make international comparisons very difficult: most research is context-specific.

- Reviews have thrown up *conflicting results*. For example, in one review, shift work was associated with poorer sleep quality among offshore nightshift workers but there was no association with poorer mental wellbeing, increased BMI or a negative impact on family/ social life (Fossum et al 2013). Conversely, Parkes (2012) data showed a positive association between shift patterns, gastric issues and poorer mental health.

- Parkes (2012) data also showed that shift work was associated with *higher rates of accident and injury*: that *adapting from night-to-day shifts typically takes longer than the converse*, and that interventions designed to assist with re-adaptation have yet to demonstrate success.

- Almost a quarter of *offshore personnel experienced SWSD* characterised by insomnia during the sleep cycle, and that these individuals were more likely to report subjective health complaints and poorer coping with their working roles (Waage et al 2009). Night shift workers in particular struggled to adapt once they were onshore (Waage et al 2012) and that 'swing shift'[22] workers more likely to report insomnia than other shift workers (Waage et al 2013).

- While there is an abundance of evidence that working shift patterns may induce and/or influence an array of negative health consequences, there is *conflicting evidence around its impact on wellbeing and on family/ social life.*

- While age[23] is not a factor in all shift working (Blok and Looze 2001), *age seems to be a key factor mitigating the physical, temporal and psychosocial impact of working offshore*. The literature cites evidence that older workers find it more difficult to adapt to day/night shift patterns, have impaired sleep quality, lower capacity for physical work, higher rates of accident/injury, poorer general health and more absences. They have also been shown to perform poorer than younger age groups on cognitive tasks (e.g. memory and attention) compared to younger age groups (Bonnefond et al 2003). No studies to date, however, have looked at ageing in relation to working time and schedules.

The above studies were conducted either exclusively on Norwegian offshore workers (e.g. Waage et al 2009, 2012, 2013) or on UK offshore workers (e.g. Parkes 2012). Common to these reviews however, is that the studies are predominantly based on workers who undertook a 2/2 working schedule. In other words, there is a high level of uncertainty about the potential impacts of a three-week on/off cycle on health in general but also on the potentially greater risk of prolonged periods of exposure offshore to health and safety issues both for individual personnel and for offshore operations. However, while there is a scarcity of literature looking at the impacts of different shift schedules, Parkes (2010) discusses a range of data on this issue and on the impact of extended overtime. We outline this evidence below.

---

[22] 'Swing Shift' is the working period between day and night shifts (e.g. 1600 hours to 0000 hours): also referred to as the 'Backshift'.

[23] Middle age is often associated with a decreasing ability to cope with shift work which appears to be related to the changing patterns of sleep in older workers. With age sleep becomes shorter and more fragmented: a shifting CR towards 'morningness' (i.e. early bed-rise) and slower adjustment which means rotational patterns are more difficult to maintain (Koh and Seng 2001).

Overtime Working Hours (the 12 hour + Shift)

Parkes (2010) notes that although offshore fatigue is observed from individual 12-hr shifts the evidence suggests that adequate recovery takes place off-shift. Also that working additional hours offshore over and above the standard 12-hr shift is not uncommon, although the amount of overtime varies widely across different occupations/ installations. Given that prolonged exposure increases fatigue (and by extension increases the risk of operational and individual accidents/ injuries) the HSE advice states that no overtime should be worked without a risk assessment, that there should be an absolute limit of 14 hours work in any one shift or any period of 24 hours, and that the normal operation of the installation should not rely on the working of overtime. An obvious point of comparison here is healthcare settings, where some researchers and reviewers strongly advocate shifts of no longer than 12 hours maximum (e.g. Ball et al 2015, Geiger-Brown 2012)

Parkes (2010) cites evidence from other workforce settings to make the point that overtime should be avoided offshore because:

- More overtime hours and prior days worked were associated with impaired cognitive performance and mood (i.e. depression, fatigue, and confusion) (Procter et al 1996).

- Extended breaks for offshore workers may mitigate the long-term adverse health consequences of working extended hours offshore (e.g. cardiovascular disease, diabetes). Findings from studies of the short-term effects of extended work hours onshore (such as fatigue, short-term cognitive impairment, low alertness, and accident risk) may be more relevant to offshore personnel than studies of long-term health outcomes.

- Accident/ risk injury increases with the length of shift hours. Overtime schedules had the greatest relative risk of occupational injury or illness, followed by those with extended daily hours (≥12 hrs) and those with extended weekly hours (≥60 hrs). Increased injury risks were not found to be due to more demanding work schedules being concentrated in ‘riskier’ occupations but long working hours indirectly precipitated workplace accidents by inducing fatigue or stress in those affected (Dembe et al 2005).

For Parkes (2010), however, managers and senior personnel who chose to work long hours unregulated by EU legislation were a more problematic offshore group in terms of long hours. Offshore managers and supervisors (typically in older age groups) who reported working more than 100 hrs/ week were found, on average, to have high anxiety and low sleep hours. Although this may generate a significant decline in their performance, some suggest that among ‘motivated personnel’ with ‘favourable psychosocial job characteristics’ (descriptions that could apply to most offshore managers) a moderate degree of overtime did not necessarily lead to increased fatigue. Nevertheless, offshore operations critically rely on managers for a whole range of tasks and safety decisions, and we should be concerned about the working hours of this group in particular.

Alternating & Fixed Shifts

The research evidence consistently demonstrates the adverse health and safety implications of individuals of adapting to nightshift patterns and in changing their day/night shift pattern mid-tour (Parkes 2010, Ross 2009). Among emergency physicians, mean total sleep time was reduced by 33% for those working night shifts vs those working day shifts (Smith-Coggins 1994). Consequently, the offshore literature highlights the increased number of 'serious' accidents among nightshift compared to dayshift workers performing the same tasks (Parkes and Swatch 1999). Studies also show that: adaptation to day-to-night-shifts usually took around a week (Barnes 1998) and may be poor or delayed (Boivin et al 2007, Drake et al 2004); and, may be seasonally dependent, and better in the 'longer daylight' seasons of March than November (Barnes et al 1998). 'Adjustment time' represents a significant portion of the offshore tour schedule whatever the rota being used by an operator.

A bigger problem however, concerns the greater circadian disruption of personnel moving from night-to-day-shift (after a possible adaptation to nightshift) (Parkes 2010). Offshore studies show that greater circadian disruption arises from: *alternating vs fixed* schedules; fixed *14 nightshift vs 14 dayshift*; and, alternating *7 days/ nights versus 7 nights/ days* (Gibbs et al 2005). Evidence in the nursing and healthcare communities shows that alternating compared to fixed shift schedules result in more sleep/wake disruption and that those on nightshift had twice the likelihood of 'nodding off' to/from work. Compared with those working fixed shifts, rotating shift workers reported a higher number of occupational difficulties and accidents. Those working an alternating schedule were twice as likely to report accidents or errors (including medication errors, work-related injuries, or accidents on the commute home), and 2.5 times more likely to report "near-miss" accidents or errors. The investigators concluded that the excessive sleepiness related to rotating shift work is associated with frequent lapses of attention and increased reaction time, leading to increased error rates (Gold et al 1992)[24]. This healthcare evidence also links in very well with a concern in the literature about post-tour onshore travel for those coming off nightshifts (e.g. Ross 2009, Parkes 2010): an obvious concern, given that three-quarters of offshore workers travel to destinations outside of Aberdeen and Aberdeenshire (Oil and Gas UK 2015).

Mapping the 'alternating' or 'rollover' shift in terms of circadian disruption is interesting in the context of different tour schedules. In two-week offshore tours personnel (if they haven't already adapted onshore) are firstly managing circadian change on their first week of tour as they adapt to 12 hour daily night shift schedules. This is then followed by a rest day before personnel adjust to a similar schedule of dayshifts before returning onshore on leave. It should however, be immediately apparent that *3/3 tours potentially involve greater circadian change* depending on the dayshift/nightshift schedule that is employed. If the message from the research literature is to minimise circadian change for individuals (and by extension minimise potential fatigue and adverse events), then it follows that the 3/3 tour schedule raises some particularly problematic issues for the design of alternating or rollover shifts across a three week period offshore. A design that has to avoid, as much as possible, the particular problems associated with night-to-day adaptation in the context of personnel finishing their tours and then travelling onshore

[24] This also puts an emphasis on the area of post-tour journeys to home following nightshift tours. These tend to be 'hidden' or 'ignored' by offshore risk management systems and there is no provision for post-tour onshore 'fatigue assessments', 'immediate rest' or for transitioning the onshore adjustment.

and home without any fatigue assessment. We return to this issue in the section below on *Risk Factors & Groups*.

The evidence for increased fatigue risk in offshore personnel with 'split' or 'alternating' shifts points strongly towards adopting fixed shift systems. For Parkes (2010) *fixed-shift patterns reduce by half the number of circadian changes* that individual personnel experience during each year of offshore day/night shift work. In view of the possible role of circadian disruption in the link between shift work and cardiovascular disease, this potential health advantage adds to the arguments for *fixed-shift* schedules and that any mid-tour changes should be mitigated by reduced individual workload and/or provision of an extra team member in the work area concerned. In the Parkes (2010) study, almost all the participants accepted that the fixed-shift rotation system led to better performance, greater alertness, and less fatigue and sleep loss, The failure of some operating companies to adopt this system was ascribed to logistical problems and a reluctance among personnel to change from their rollover patterns.

It is also worth noting that a 3 week offshore break may be more beneficial for personnel as circadian re-adaptation for night shift personnel coming off tour can take up to 4-5 days onshore.

Recommendations for facilitating adjustment to shift rotation have included: the appropriate lighting of work areas to enhance alertness and performance (e.g. using blue-enriched white light), and the use of bright light to reduce the time required for adaptation to night work, and re-adaptation to a daytime circadian cycle. Caldwell et al (2008) also outline a series of management strategies designed to facilitate the maintenance of alertness in operational settings including those that involve day/night work. These recognise that in an offshore environment fatigue/sleepiness is temporarily unavoidable because of the nature of shift working and long hours but they also try to mitigate against fatigue arising from poor personal choices and recognise that some individuals and groups (e.g. older workers) may be more vulnerable to the effects of sleep loss than others. These measures include:

- Adequate work/rest scheduling.
- Sleep hygiene measures (e.g. regular routines, avoiding caffeine, etc).
- Sleep-inducing medications and strategic napping.
- Limiting time on tasks.
- Sleep education.

Working Shift Patterns

Until relatively recently the UK offshore industry mainly used 2/2 tours (similar to Dutch North Sea operators) with smaller numbers of personnel having three weeks onshore (i.e. 2/3): a mix of schedules across occupations within installations which largely operated up until the mid-1990s: their utility based on their ability to attract/retain skilled personnel and provide adequate shore leave. By way of contrast, Norwegian operators in the North Sea provide four weeks onshore (i.e. 2/4). However, as the West of Shetland area opened up in the early 2000's, a smaller number of operators began to employ 3/3 schedules reflecting the relative remoteness of this offshore environment and the need to minimise operational costs. For personnel in this area three-week tours have the added advantage of reducing helicopter flights and overall trip travel time, with longer onshore leave, which may outweigh the disadvantages of longer tours.

In an economically 'struggling' and challenging market for oil revenues and employment, there have now been moves towards introducing 3/3 tour schedules in the UK North Sea sector, similar to those currently operating in West of Shetland and in the Gulf of Mexico: a system that potentially increases the operational and health risks to North Sea personnel of longer periods offshore. Parkes (2010), however, highlights that research that has systematically tracked the cognitive performance, alertness and sleep of day-workers offshore has *not observed performance impairment or other signs of fatigue increasing progressively* over the two-week offshore tour. Although fatigue was observed in individual during 12-hr shifts, the prevailing evidence suggests that adequate recovery takes place off-shift. Relatively few studies, however, have compared the health and safety outcomes in terms of the duration of working schedules onshore/ offshore: with the aim of assessing whether longer tour durations offshore increase the risk of injury, fatigue and accidents. As Parkes (2010) outlines, hard evidence of any adverse effects on objective measures of operational or individual health and safety risks is extremely scarce. In the UK offshore industry, only Parkes (2010) has looked at this issue in depth and in the context of comparing 2/2 week and 3/3 week working schedules in terms of subjective wellbeing, sleep and satisfaction, accident patterns and spouse/ family concerns. The findings of this analysis are summarised below.

- There was *no clear evidence of adverse effects* on sleep, alertness and perceived workload of a third week offshore, although there was a weak trend of reduced alertness across successive weeks of a 3/3 schedule. This was explained by habituation/expectation and workers being able to adapt to 'planned' and 'expected' durations offshore. Only when tours were unexpectedly extended (e.g. in poor weather conditions) did they give rise to more marked problems of adaptation.

- Offshore personnel on production installations reported *less satisfaction with 3/3 than 2/2 schedules*. Less than 1 in 5 personnel on fixed platforms were satisfied with 3/3 schedules (16%) while the remainder reported a preference for 2/2 schedules. In contrast, among drilling rig personnel, nearly half those working 3/3 schedules reported that they preferred this working pattern. In other words, 2/2 and 3/3 schedules were preferred by different groups of offshore personnel with the majority opting for a 2/2 tour. Spouses/ partners of offshore workers were also more critical of 3/3 tours (compared with 2/2) (Parkes and Clarke 1997).

- While large-scale industry accident/injury data do not allow comparisons in terms of different tour working schedules, Parkes and Swash (2000) calculated 'severity' ratio's using HSE and industry data. These results showed that the *severity ratio increased steeply for the third week offshore* relative to the first two weeks. This implied that an injury occurring in the third week was significantly more likely to be severe. However, in this study, the actual number of injuries in the third week was small as compared with the first two weeks (i.e. relatively few personnel worked three-week tours). Whilst the results could imply that fatigue resulting from long tours is an underlying factor affecting injury severity, the limited nature of their data analysis did not allow a clear causal interpretation. In particular, an alternative explanation of the findings was that tours of three weeks duration were more likely to be operated on older installations with less rigorous safety procedures. In other words, the data may have been an artefact of the age of the working environment.

- Conversely, introducing a regular three-week shore break has a favourable effect on the morale of offshore workers and their families. A three week break is beneficial and brings the UK offshore workers closer to the four weeks off schedule employed in the Norwegian sector. Extending the onshore break would be expected to have a positive impact on the performance and wellbeing of individual offshore workers and, in the longer term, on the productivity and safety record of the installations concerned. Nevertheless, Parkes (2010) notes that by extending shore breaks to three weeks this may reduce the ability of personnel to *maintain situational awareness* of operating processes, and the performance 'sharpness' or 'readiness' of offshore personnel, over the weeks on leave. Handover procedures become particularly important following longer shore breaks, possibly augmented by 'pre-mobilization briefing' sessions to update personnel on any changes that may have occurred while they were on leave.

The above data does offer some degree of health, safety and 'risk' leeway for Trade Unions on the issue of 3/3 tour schedules. The key issue is how these three week tours can be designed to minimise potential risks. Yet at this stage there is very little concrete evidence to conclude anything much beyond the concerns of researchers that these schedules may have a significantly more negative impact on performance and fatigue among offshore personnel. The issue of fatigue would be a particular concern for those in older age groups and/or those in roles involving heavy physical activity or in tasks requiring high vigilance and a low error tolerance over the course of a three week tour. Parkes (2010) concluded that there is a need for an extensive evaluation of the possible effects of fatigue and performance impairment especially during the later stages of the 3-week tour period. While the research evidence does not suggest that significant performance impairments are associated with two-week periods of day work offshore, the situation in relation to an extended regular three-week offshore tour is far more uncertain, concerning and open to speculation. In short, the current available evidence does not allow clear conclusions to be drawn about whether working regular three-week tours poses significant health and safety risks but as we have outlined in the evidence above there are suggestions that this may indeed be the case. While, data from onshore studies suggest that there may be adverse effects of fatigue from extended periods of intensive work, the extent to which these findings are applicable to the offshore environment (where three-week work periods alternate with similar periods of shore leave) remains to be determined (Parkes 2010).

If the data were available and accessible it would be interesting for example, to compare data on accident/injury rates and severity ratios between comparable installations in the North Sea operating 2/2 and 2/3 tours versus those in West Shetland operating 3/3 tours. This would allow a direct statistical analysis of the impact of these different tour schedules on these variables. More practically, however, it should at least put a very sharp focus on the existing safety management systems used by current North Sea offshore operators. There will be a requirement that these safety systems proactively *monitor* the impact on individual performance and health of the switchover to a 3/3 schedule. The research evidence also suggests that these monitoring systems should also be extended to account for any post-tour travel onshore, particularly for those coming off nightshift.

A further avenue of research may also be pursued through smaller-scale and more cost-effective qualitative work with those coming off 3/3 tours. A small scale structured (by age and working role) qualitative study could provide very useful evidence of the experience of this shift pattern compared to others, or use this evidence in tandem with workers using diaries over the period of their tour to record their experiences as they complete shifts. A striking feature of the literature to date has been its overwhelming use of quantitative (mainly surveys) methods or using HSE data which while useful in generating volumes of data, provide very little depth and insight on the individual experience of working offshore and fatigue. Studies have often very little to say about this experience from the perspective of individual personnel and more depth is sometimes required to interpret survey findings (Gibson-Smith et al 2015).

Risk Factors & Groups

From the above literature and in addition to the structural HSE risk hazards outlined in Chapter 2, there are a number of other areas of health and safety concern that could be particularly problematic in a three week tour offshore. These are:

- *Fatigue* especially towards the end of the three week period working offshore.
- Increased potential of *severe accidents* in the third week of the tour.
- Offshore *tours that extend* (e.g. because of weather conditions especially during winter) beyond the three week working period.
- The operation of *mid-shift changes in rotation* (e.g. switching from day-to-night shift from night-to-day shift) with adequate adjustment measures built into the shift design to minimise circadian disruption.
- *Excess overtime* beyond 12-14 hours per day.
- Tours on *older installations* with potentially higher 'severe' accident ratios, or those installations with cabin accommodation areas that do not allow for *adequate rest* after shifts.
- Management and supervisory personnel who already work *excessive hours* on tours.
- The potential impact on more '*vulnerable' groups such as 'older' workers* where intensive physical demands over a three week period may be more likely to negatively impact on health among these groups. This may especially arise when they are on nightshift duties and/or where they are in supervisory roles with monotonous tasks that require vigilance.

Given the relative unrelenting intensity in much offshore work, the literature typically points to concern about individual fatigue towards the end of duty tours. It should be clear that moving from a 2/2 to a 3/3 schedule may involve more serious accidents (particularly on nightshifts) and potentially extends an already intense workload, including all those low-error tolerance tasks conducted by offshore personnel.

One benefit of the 2/2 design is that it neatly divides 'rollover' shifts (i.e. 50% dayshift and nightshift respectively) over the course of an individual tour. Picking up again on the earlier discussion of fixed vs alternating shifts, it should also apparent that even in a research literature with many 'gaps', the issue of what shift schedule any operator should employ is slightly more complex in the context of a 3/3 tour. This is particularly so if the aim of any 'rollover' schedule is to optimise safety by minimising circadian change and individual fatigue. Yet we are unable to find any existing research and guidance on what operators should optimally do in these circumstances for a 3/3 design. These 3/3 designs raise the problem of greater circadian change - acknowledged as generally 'harder' on those in older age groups - and the prospect of more personnel finishing tours from nightshift than dayshift positions. This may not only mean putting in place more stringent monitoring systems towards the end of three week tours but also having more 'rest breaks' on tours, more support personnel on shift and more attention given to post-tour fatigue assessments before personnel journey home. In the literature, the key factors to reduce potential fatigue are having appropriate:

- Pre-mobilisation briefings on changes for crew returning offshore.
- Numbers of personnel who can provide cover and support on shifts, particularly those working at night.
- Minimising the numbers of personnel who finish tours on nightshifts.
- Numbers of rest breaks on shifts.
- Discretion to allow personnel some measure of self-regulation to set their own task completion and length of rest breaks during shifts.
- Closer monitoring of those on their third week of tour, particularly those engaged in low tolerance/high error or high vigilance tasks.
- Lighting for those on night shifts.
- Ensuring cabin accommodation arrangements provide 'rest' post-shift.
- Fatigue assessments for those coming off a 3/3 tour before they travel home.

4. SUMMARY & CONCLUSIONS

The offshore industry is dominated by an operational cycle of a 24/7 working schedule that relies on long hours and alternating shift schedules in remote environments. Like many other workers in other safety critical industries where there are legislative limits to continuous working hours, offshore workers are exposed to an environment where fatigue may have serious operational and individual health and safety consequences. Although working hours and shift patterns are managed by HSE within the context of the WTR, recent developments in the North Sea sector have seen a move towards extended three week tours as operators attempt to cut costs in an industry suffering from reduced profitability and investment, and job losses.

Long hours and shift working have long been associated with a range of negative health consequences for individuals, particularly fatigue. This has been a longstanding concern across many shift working occupations, especially those in safety critical roles. Although offshore workers have been actively researched in relation to a range of health issues, the literature has a number of significant gaps regarding long hours, shifts and evaluating the strengths and weaknesses of different working schedules. The evidence that is available on these matters shows that:

- shift work offshore disrupts normal circadian cycles and is linked with poorer sleep quality, impaired alertness and decreasing task performance, with higher rates of accident and injury, and that adapting from night-to-day shifts typically takes longer than day-to-night shifts. Although there is conflicting evidence around the impact of working offshore on wellbeing and on family/ social life, age does seems to be a key factor mitigating the physical, temporal and psychosocial impact of working in these environments.

- As in other SCW settings, offshore fatigue and its negative effects on performance and link with accidents/ injuries may be exacerbated by extended working hours (above 12 hours/day) and by alternating or rollover shifts. The literature has recommended a range of measures to help offshore workers manage alertness and fatigue, and HSE points to a range of particular fatigue ‘hazards’ that should be avoided to minimise any negative effects of working offshore and optimise operational and individual health and safety. The most critical of these ‘hazards’ could be argued to be ‘fatigue’ in the context of low-error tolerance and high vigilance tasks, and tasks involving physical labour.

- Much of the offshore evidence comes from studies on workers who have undertaken 2/2, 2/3 and 2/4 working schedules. There is comparatively little evidence on the impact of the trend in the North Sea towards 3/3 schedules, although the effects of a standard three week break onshore are likely to be beneficial so long as ‘situational awareness’ among returning personnel is actively managed.

- In relation to the effects of fatigue arising from 3/3 schedules, while the research evidence does not suggest that fatigue accumulates progressively over the period of a tour, or that significant performance impairments are associated with two-week periods of day work offshore, the situation in relation to an extended regular three-week offshore tour is far more uncertain, concerning and speculative. The literature strongly recommends an extensive evaluation of the effects of three week tours offshore.

- There are a number of areas of particular concern for personnel on 3/3 tours. These include issues such as extended working hours, alternating shift schedules, extended tours, the severity of injuries/accidents particularly on older installations and fatigue towards the end of the tour. Three week tours may require not just more extensive evaluation but the operation of more stringent monitoring systems and measures (e.g. more rest breaks, cover, lighting and adaptation procedures) to reduce individual fatigue.

REFERENCES

American Academy of Sleep Medicine (2005). *The International Classification of Sleep Disorders: Diagnostic & Coding Manual, ICDS-2*. 2nd ed. Westchester, Ill: American Academy of Sleep Medicine.

Angus R.B. and Heslegrave, R.J. (1995) Effects of sleep loss on sustained cognitive performance during a command and control simulation. *Behavioural Research Methods Instruments Computers*, 17:55-67.

Ball, J., Maben, J., Murrells, T., Day, T., Griffiths, P. (2014) *12-hour shifts: prevalence, views and impact*. National Nursing Research Unit, King's College London.

Barnes, R. G., Forbes, M. J., & Arendt, J. (1998). Shift type and season affect adaptation of the 6-sulphatoxymelatonin rhythm in offshore oil rig workers. *Neuroscience letters*, *252*(3), 179-182.

Belenky, G. et al (1994). The effects of sleep deprivation on performance during continuous combat operations. In: Marriott B, ed. *Food Components to Enhance Performance*. Washington, DC: National Academy Press, 127-135.

Boivin, D. B., Tremblay, G. M., & James, F. O. (2007). Working on atypical schedules. *Sleep medicine*, *8*(6), 578-589.

Bonnefond, A., Rohmer, O., et al. (2003). Interaction of age with time of day and mental load in different cognitive tasks. *Perceptual and Motor Skills*, **96**, 1223-1236.

Blok, M.M and Looze, M.P. (2011) What is the evidence for less shift work tolerance in older workers? *Ergonomics*, 54 (3) 221-

Boggild, H., & Knutsson, A. (1999). Shift work, risk factors and cardiovascular disease. *Scandinavian Journal of Work, Environment & Health, 25*, 85-99.

Bonnet, M.H. and Arand, D.L. (2003) Clinical effects of sleep fragmentation versus sleep deprivation. *Sleep Medicine Review*, 7:297-310.

Burgess, H. J., Sharkey, K. M., & Eastman, C. I. (2002). Bright light, dark and melatonin can promote circadian adaptation in night shift workers. *Sleep Medicine Review*, *6*(5), 407-420.

Caldwell J.A. and Caldwell J.L. (2005) Fatigue in military aviation: an overview of U.S. military-approved pharmacological countermeasures. *Aviation Space Environmental Medicine* (Supplement), C39-51.

Caldwell, J.A. et al (2003) The Effects of 37 Hours of Continuous Wakefulness on the Physiological Arousal, Cognitive Performance, Self-Reported Mood, and Simulator Flight Performance of F-117A Pilots. Brooks City-Base, Tex: *US Air Force Research Laboratory. Technical Report No: AFRL-HE-BR-TR-2003-0086.*

Caldwell, J.A., Caldwell, J.L. and Schmidt, R.M. (2008) Alertness management strategies for operational contexts. *Sleep Medicine* 12(4), 2757-273.

Costa, G. (2003) Shift work and Occupational Medicine: an Overview. *Occupational Medicine* (London), 53:83-88.

Dembe, A. E., Erickson, J. B., et al. (2005). The impact of overtime and long work hours on occupational injuries and illnesses: New evidence from the United States. *Occupational Environmental Medicine,* **62**, 588-597.

Dinges. D.F. (1995) Technology/Scheduling Approaches. In *Proceedings: Managing Fatigue in Transportation: Promoting Safety and Productivity*. Washington, DC: National Transportation Safety Board and NASA-Ames Research Center, 35-41.

Doig, M. (2007) Offshore Workers. In Palmer, K.T., Cox, R.A. and Brown, I. (Eds) *Fitness for Work: the Medical Aspects*. Oxford: Oxford University Press.

Drake, C. L., Roehrs, T., Richardson, G., Walsh, J. K., & Roth, T. (2004). Shift work sleep disorder: prevalence and consequences beyond that of symptomatic day workers. *Sleep*, *27*(8), 1453-1462.

Faculty of Occupational Medicine of the Royal College of Physicians (2006). *Guidance on alcohol and drug misuse in the workplace*. London: The Faculty of Occupational Medicine.

Fossum, I.N., Bjorvatn, B., Waage, S., Pallesen, S. (2013) Effects of shift and night Work in the Offshore Petroleum Industry: A Systematic Review. *Industrial Health* 52 (5), 530-544.

Geiger-Brown, J., Rogers, V., Trinkoff, A., Lane, R., Bausell, R. & Scharf, S. (2012) Sleep, sleepiness, fatigue and performance of 12-hour shift nurses. *Chronobiology International*. 29 (2): 211-219.

Gibbs, M. et al (2005) Effect of Shift Schedule on Offshore Shift Workers' Circadian Rhythms and Health. Report to *Health and Safety Executive. Research Report 318*. University of Surrey: Guildford.

Gibson Smith, K, Paudyal, V., Stewart, D. & Klein, S. (2015) *The Health and Wellbeing of Offshore Workers: a Narrative Review of the Published Literature*. ISSU.

Gold, D. R., Rogacz, S., Bock, N., Tosteson, T. D., Baum, T. M., Speizer, F. E., & Czeisler, C. A. (1992). Rotating shift work, sleep, and accidents related to sleepiness in hospital nurses. *American journal of public health*, *82*(7), 1011-1014.

Horne, J.A. (1978) A review of the biological effects of total sleep deprivation in man. *Biological Psychology*, 7:55-102.

House of Commons Transport Committee (2013) *Flight Times Limitations: Follow Up. Sixth Report*. London: House of Commons.

HSE (2008) *Guidance for managing shiftwork and fatigue offshore: offshore information sheet ref:7/2008*. HSE Press: London.

HSE (2012) *Managing Shiftwork*: HSG256, HSE Press: London.

HSE (2014) *Offshore Oil and Gas Sector Strategy 2014 to 2017*. HSE Press: London.

HSE (2015) *Annual Offshore Statistics & Regulatory Activity Report 2014/2015*. HSE Press: London.

Koh, D. and Seng, C.K. (2001) *Textbook of Occupational Medicine Practice* (2nd Edition). London: John Wiley.

Krueger, G.P. (1991) Sustaining military performance in continuous operations: combatant fatigue, rest and sleep needs. In: Gal, R., Mangelsdorff, A.D. (eds), *Handbook of Military Psychology*. Chichester, United Kingdom: John Wiley & Sons, Inc.; 1991:255-277.

Miller, N. L., Matsangas, P., & Shattuck, L. G. (2008). Fatigue and its effect on performance in military environments. In P. A. Hancock & J. L. Szalma (Eds.), *Performance under stress* (pp. 231–249). Hampshire, England: Ashgate Publications.

Monk, T.H. & Folkard, S. (1992) *Making Shift Work Tolerable*. Taylor & Francis, London.

Occupational Medicine (2012) *Editorial on Safety Critical work, Ageing and Cognitive Decline*. 62 (7) 480-482.

Ohayon M.M., Lemoine, P., Arnaud-Briant, V., Dreyfus, M. (2202) Prevalence and consequences of sleep disorders in a shift worker population. *Journal of Psychosomatic Research*. 53:577-583.

Oil & Gas UK. (2015). *UKCS Workforce Demographics Report*. London: Oil & Gas UK.

ONS (2011) *Changes in Shift Work Patterns Over the Last Ten Years (1999 to 2009)*. Report for the HSE (RR887). ONS:Newport.

Parkes, K.R. (2010) *Offshore Working Time in Relation to Performance, Health and Safety: A Review of Current Practice and Evidence*. Report to Health and Safety Executive (RR772). University of Oxford: Oxford.

Parkes, K. R. (2012) Shift Schedules on North Sea Oil/Gas Installations: A Systematic Review of their Impact on Performance, Safety and Health. *Safety Science* 50 (7): 1636-1651.

Parkes, K. R., & Clark, M. J. (1997). *Psychosocial aspects of work and health in the North Sea oil and gas industry. Part V. Offshore work/leave schedules: data analysis and review*. (OTO 97 012). London: Health and Safety Executive.

Parkes, K. R., & Swash, S. (2000). *Injuries on offshore oil and gas installations: An analysis of temporal and occupational factors* (OTO 1999-097). London: Health and Safety Executive: Offshore Safety Division, OTO 1999-097.

Proctor, S. P., White, R. F., et al. (1996). Effect of overtime work on cognitive function in automotive workers. *Scandinavian Journal of Work, Environment & Health*, **22**, 124-132.

Ross, J. K. (2009). Offshore industry shift work - health and social considerations. *Occupational medicine*, *59*(5), 310-315.

Scott, A.J. and La Dou, J. (1999) Shiftwork: effects on sleep and health with recommendations for medical surveillance and screening. *Occupational Medicine*, 5:273-299.

Smith-Coggins, R., Rosekind, M.R., Hurd, S. and Buccino, K.R. (1994) Relationship of day vs night sleep to physician mood and performance. *Annals of Emergency Medicine*, 24:928-934.

TUC (2013). Working Time - In *Hazards at Work*. London: TUC. See *https://www.tuc.org.uk/workplace-issues/working_time.cfm*.

Shields, M. (2002) Shift work and health. *Health Reports*, 13:11-33.

Shiftwork Practices 2004. Lexington, Mass: Circadian Technologies, Inc.

Waage, S., Moen, B.E., Pallesen, S., Eriksen, H.R., Ursin, H., Akerstedt, T. (2009) Shift Work Disorder Among Oil Rig Workers in the North Sea. *Sleep* 32 (4) 558-565.

Waage, S., Harris, A., Pallesen, S., Saksvik, I.B., Moen, B.E., Bjorvatn, B. (2012) Subjective and Objective Sleepiness Among Oil Rig Workers During Three Different Shift Schedules. *Sleep Medicine* 13 (1) 64-72.

Waage, S., Pallesen, S., Moen, B.E., Bjorvatn, B. (2013) Sleep and Health in Oil Rig Workers - Before and After a Two Week Period Offshore. *Industrial Health* 51 (2) 172-179.

Woolfson, C., Foster, J. and Beck, M. (1996) Paying for the Piper: Capital and Labour in Britain's Offshore Oil Industry. London: Routledge 1996.