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Sleep, watchkeeping and accidents: a content analysis of incident at sea reports

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Abstract

The unique profession of seafaring involves rest and sleep in a 24-h-a-day work environment that usually involves time-zone crossings, noise, heat, cold and motion. Sleep under such conditions is often difficult to obtain, and sleeping and sleep loss are often related to fatigue and contributory to accidents. This study aims to determine how accident investigators report sleep in Incident at Sea Reports and subsequently analyse the relationships between sleep, fatigue and accidents in these reports.

The full text of 44 Incident at Sea Reports was coded and analysed using NUDIST software. This sample included collisions and groundings reported since 1991, where significant human factors contributed to the incident. The Incident at Sea Reports were electronically searched for reference to sleep and content was indexed against parameters such as fatigue behaviours, time of day and contributing personnel. Incident at Sea Reports incorporate three levels of reference to sleep, analysis of which may associate sleeping and sleepiness with accident causation. The highest level of reference unequivocally associates either being asleep, or being sleep deprived with accidents, but not always with fatigue. At an intermediate level, reference to the conflicting pressures of work and sleep on board fishing boats and ships suggests a work environment that is not conducive to obtaining sufficient sleep, and accident investigators are usually unable to link the watch-keeping environment with fatigue as a contributing factor. At the lowest level of association, reference is made to the integrated nature of sleeping and work on board.

Keywords: Naval medicine; Fatigue; Sleep deprivation; Accident prevention; Task performance and analysis

1. Introduction

Seafaring has been described as the original 24-h society (Filor, 1996). Commercial vessels employ a ship's crew of a master and two or three deck officers, engineering officers and a

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complement of integrated ratings. These personnel may be engaged in navigation, cargo handling, communication, emergency response, maintenance, catering, administration and human resource management in a closed community that is isolated physically and socially from other vessels and from shore-based life (National Competency Standards for the Maritime Industry, 1993). These activities take place 24 h a day, for every day that the vessel is in commission.

Watchkeeping is the responsibility of deck officers, who comprise the master and first and second mate (and perhaps a third mate), typically operating a three-watch system. The first mate takes responsibility for the 4–8 watch, the second mate the 12–4 watch and the third mate and/or the master the 8–12 watch. Ships' officers therefore have two 4-h watches per 24-h period. In addition to watchkeeping, officers have other duties; the first mate manages mooring and unmooring operations and cargo handling, and the master has overall responsibility for command of the vessel and the safety of crew, specific manoeuvring operations, monitoring, budget, information control and security.

Smaller vessels such as fishing boats typically have a skipper and one or two deck hands, who operate a watchkeeping system based around fishing activities. For example, prawn trawling is a night-time activity with the crew sleeping during the day. Travelling to and from the fishing grounds, cleaning and stowing the catch and getting the catch to markets frequently involves extended periods of wakefulness and it is common for the entire ship's complement to sleep at anchor or to lie ahull between fishing activities.

The human need for regular and extended periods of sleep is often at odds with the ongoing nature of shipboard activities. Just as time and tide wait for no man, ship operations must continue around the clock due to economic (time) and navigational (tide) pressures; the physiological needs of the crew are frequently left wanting.

Sleep, sleeping and sleep deprivation are therefore central issues in the life on board commercial ships and fishing boats. Several studies illustrate that watchkeepers suffer lower quality and fragmented sleep, accruing substantial sleep debt and exhibiting critical fatigue behaviours (Cook & Shipley, 1980; Berger, 1984; Rutenfranz et al., 1988; Sanquist, Raby, Forsythe, & Carvalhais, 1997; Parker & Hubinger, 1998).

In Australia, the Marine Incident Investigation Unit of the Department of Transport has statutory responsibility to investigate incidents at sea as defined in the Navigation (Marine Casualty) Regulations and specified in the Navigation Act of 1912. Since 1991, this unit has published 115 Incident at Sea Reports and made available another 26 previously published reports. Nine incidents are currently under investigation with reports pending. Full text of these reports is available from the Marine Incident Investigation's web site at www.miiu.gov.au/index.htm.

2. Methodology

2.1. Sampling criteria

This study involved a content analysis of a sample of 44 Incident at Sea Reports. The sampling criteria included reports where human factors contributed to the incident (i.e. excluding fires, foundering and injuries to crew and collisions and groundings where the main contributing factors

were weather and equipment failure). In the main, this comprised collisions and groundings; however, one report of injury and one of over-pressurisation were included due to the involvement of substantial human error. Reports prior to 1991 were excluded due to the heterogeneous nature of these earlier reports, the newly formed MIIU adopting a pro forma for incident reporting from this date.

2.2. Content analysis of Incident at Sea Reports

Incident at Sea Reports were scanned using optical character recognition software or downloaded from the Marine Incident Investigation Unit Web site (http://www.miiu.gov.au) and imported into NUDIST (Non-Numerical Unstructured Data Indexing, Searching and Theorising software, version 4.0 – Qualitative Solutions and Research Pty. Ltd). NUDIST is a program designed for the storage, coding, analysis and retrieval of text and is regarded by Weitzman and Miles (1995) as "one of the best thought out qualitative analysis programs around" (for a discussion on the use of computers in qualitative analysis see Richards & Richards, 1994). NUDIST accommodates an indexing system of nodes (categories of related text units) and documents can be displayed, browsed and searched using Boolean, set logic, and sophisticated matrix and vector operators.

The paragraph was chosen as the unit of analysis and is termed a "text unit" by NUDIST. The 44 reports comprise some 6208 total paragraphs (an average of 141 paragraphs per report). Reference to sleep made by accident investigators was determined by conducting a text search for sleep and related words (such as sleep, slept, asleep, rest, wake, awake, alert, bed etc.).

2.3. Coding strategy

Reference to sleep was coded into three levels of possible association with accident (high, medium and low) and five descriptive categories (see Table 1). Three of the five categories were subsequently subdivided into specific, described behaviours or factors.

Table 1
Accident investigators' reference to sleep

Descriptive category and level of contribution	Behaviour/factor	Number of references
Sleeping as contributory (high level of contribution)	Watchkeeper asleep on watch	13
	Crew asleep at anchor	6
	Master or pilot asleep	12
Sleep loss as contributory (high level of contribution)		27
Sleep loss as a way of life (medium level of contribution)	Waking at odd hours	28
	Daytime sleep	13
	Working, not sleeping	5
	Sleep hygiene	16
Rest rather than sleep (medium level of contribution)		37
Sleep as routine (low level of contribution)	Sleeping accommodation	7
	Sleep routine	60

(The term *associate* is used here to infer some possible degree of involvement of one factor with another. The term *contribute* is the term used by accident investigators to infer a causal relationship between one factor and a consequence.)

3. Results

3.1. Quantitative analysis

Accident investigators made reference to sleep in 38 of the 44 (86%) reports analysed. Of the 44 incidents analysed, 21 were groundings and 21 were collisions, the remaining two comprising an injury and a tank over-pressurisation.

Most references (34%) were made to sleep loss as a way of life (waking at odd hours, daytime sleep, working instead of sleeping and sleep hygiene factors) followed by sleep as routine (28%) (See Table 1).

In the study sample, there were 11 collisions and eight groundings on day watches (0800 to 0000) compared to 10 collisions and 13 groundings on night watches (0000 to 0800).

Seventy-seven percent of all sleep references corresponded to incidents that occurred during the first two watchkeeping periods (i.e. 0000 to 0800) with 49% of all sleep references corresponding to the first watch (0000 to 0400) alone. There were only 6 sleep references (2.3%) inferring a high level of contribution to accidents that occurred during the four daytime watchkeeping periods (i.e. 0800 to 0000) compared to 53 sleep references (21%) that occurred during the two night watches (i.e. 0000 to 0800).

Accident investigators' reference to sleep was evenly distributed between collisions and groundings (with 125 references in groundings, 119 references in collisions and nine references in other incidents).

Groundings contained more references to sleep loss and sleep deprivation (29) than collisions (22 references). Groundings also contained more references to sleep loss as a way of life than collisions (52, compared to 45 references). The sleep routine was referred to in more collisions than groundings (45, compared to 27 references). Reference to being asleep was associated with twice as many collisions (8) as groundings (4), whereas being sleep deprived corresponded to twice as many groundings (4) as collisions (2).

The master was the major human contributor in 12 of the 44 incidents, the second mate in nine, and the pilot in eight incidents. Association of the master with accidents occurred across all watches, but predominantly on both 0400 to 0800 watches. The second mate was predominantly associated with accidents during the 0000 to 0400 watch, whereas the pilot's association followed a similar distribution to the master. It is noteworthy that the second mate was associated with twice as many incidents in the 0000 to 0400 watch-keeping period as any other officer in any other watchkeeping period.

Behaviours of the pilot were associated with seven groundings, but only one collision, whereas behaviours of the second mate were associated with six collisions and only two groundings. Ship's masters were associated with six groundings and five collisions.

3.2. Accident investigators' reference to sleep in Incident at Sea Reports

Accident investigators report sleep at three levels of association with accidents. Being asleep on watch or being sleep deprived are conditions classed at the highest level of association with accidents – the condition is usually contributory to the accident. Reference to seafarers being woken at odd hours, sleeping during the day, working or resting instead of sleeping, and sleep hygiene issues describes a moderate level of association with accidents. Accident investigators also frequently refer to sleeping accommodation and the sleeping routine on board. These conditions have the lowest level of association with accidents.

Reference to sleep by accident investigators does not always correspond with fatigue being determined a contributing factor to an incident at sea. For example, the investigator determined in three out of four incidents where the watchkeeper was asleep on watch that fatigue was a factor. However, the investigator determined that fatigue was not a contributing factor in the three incidents where all the crew were asleep on board vessels at anchor or lying ahull (not under command), even though it is a requirement to maintain a watch at sea. Though being asleep was a contributing factor to the accident, fatigue was not. In each of the latter incidents, the two crew members of fishing boats were asleep following a period of fishing activity, the 24-h work schedule making it extremely difficult to maintain the lookout required by regulations.

Accident investigators have identified seven incidents where the master or pilot was asleep when the incident occurred. In five instances, skippers of fishing vessels had handed over to an unqualified crew member to get some sleep. Once again, though fatigue was not a determined a contributing factor by accident investigators, sleeping of critical crew members certainly was. In two instances on commercial ships, the master, or the pilot and the master were asleep when the watchkeeper became incapacitated through fatigue. In these two incidents, the sleep condition of the critical crew members was associated with the accident and the fatigue state of the watchkeeper was contributory.

Twenty-seven references to sleep loss are made in eight reports, fatigue being determined as contributory in seven of these incidents. Seven of these eight incidents occurred on watches between 0000 and 0800. Work factors identified by accident investigators as predisposing to a sleep-deprived state included excessively long shifts, the nature of the work routine and disrupted sleep patterns. In addition, jet-lag was identified as a predisposing factor where ship's officers travelled long distances to take up their command without having sufficient time to adjust to the new time zone. The possibility of sleep disorders such as sleep apnoea, and self-imposed sleep loss due to the need for socialisation were identified by investigators as predisposing factors in individual cases.

There are 22 references to waking at odd hours (16 reports), 15 of which correspond to reports where accident investigators determined that fatigue was a contributing factor. Seven references to waking at odd hours refer to waking to take over the watch. Other references include pilots being called to the bridge for pilotage duties, the master being called to the bridge due to fog or to wait a pilotage transfer, fishing boat crew waking to attend to nets and, in three instances, waking following a grounding or collision.

Daytime sleeping is referred to 13 times in nine reports. Most references to this are to crew members of fishing boats engaged in night-time fishing (such as prawn trawling). Remaining references to daytime sleep are to sleeping following or preceding a night watch or pilotage. Daytime sleeping in fishing boats at anchor or not-under-command is associated with the risk of

collision with commercial vessels that fail to maintain a proper lookout. In some instances, fishing vessels may not be exhibiting the correct lights and, in the early morning hours, risk being run down by commercial vessels.

Accident investigators make five references to watchkeepers working instead of sleeping while off watch. In addition to watchkeeping, officers also supervise loading and unloading operations in port, write reports, conduct exercises and drills, supervise staff and manage aspects of ship operations. Reference to these additional duties competing with sleep time is made in five instances. In one instance, the master was on the bridge for 16 out of 28.5 h but did not consider himself tired (investigators subsequently finding the master partially contributory to a collision). Another report describes a master writing a report to the shipping company at 0100 following his watch (during which the sleep-deprived pilot lost situational awareness and the vessel ran aground). Fishing boat skippers are often described as working alone, steaming to and from the fishing grounds, fishing and selling the catch and fishing during the day.

Sixteen references (in six reports) to environmental and sleep hygiene factors illustrate some of the difficulties associated with sleeping aboard ships and fishing boats. One fishing boat skipper bunked in the wheelhouse so as to be instantly available, and reference is made to deckhands on prawn trawlers sleeping between winching prawn nets, cleaning and packing prawns, the intermittent nature of the job hardly being conducive to sleeping.

Investigators raise three critical sleep hygiene issues in two reports. Firstly is the need for socialisation and activity outside the operational routine on board. In the case of the Svenborg Guardian (Incident no. 82), the already fatigued ship's crew watched a Rugby Union match on television, an action that contributed to the second mate falling asleep in his cabin during the 0000 to 0400 watch. Watching late night sport on television is hardly an issue in many land-based jobs; however, the failure of the second mate to remain vigilant during his watch due to watching evening television was described by the investigator as "... displaying inexperience and irresponsibility".

The second sleep hygiene factor relates to the influence of occupational stress on sleep. One incident (Peacock, Incident no. 95) refers to changed conditions of service of pilots, resulting in anxiety and stress, and affecting an individual's sleep and concentration.

Thirdly, in the same report, investigators make reference to the possibility of sleep disorders such as sleep apnoea and snoring affecting the quality of sleep. Though it may be difficult for accident investigators to retrospectively evaluate the effect of sleep disorders, they are valid in identifying body weight, diet, domestic and occupational concerns, snoring and daytime sleepiness as factors possibly contributing to fatigue and hence to accidents.

Accident investigators occasionally refer to sleeping accommodation. Each of the seven references is to the general layout of sleeping accommodation in fishing boats. No reference is made to the sleeping arrangement on commercial vessels. Fishing vessel sleeping berths are commonly described as being below deck, usually accessed from the forecastle, the wheelhouse or a separate companionway from the deck. Because of the integrated nature of work on fishing boats, coupled with the small crews, accommodation is usually combined with the working areas of a fishing vessel. For example, the galley and sometimes a skipper's berth share space in the wheelhouse, and sleeping accommodation for the deckhands is usually under the working deck adjacent to the fish hold.

Seafarers on commercial vessels enjoy a separate accommodation block that is remote from the operational areas of the deck, holds and bridge. Master's and pilot's cabins are usually close to the bridge.

4. Discussion

4.1. Sleep and sleep deprivation

At the time of Cook's voyage to Australia, regulations for watchkeeping were brief, article XXVII of the Kings Regulations and Admiralty Instructions stating that "No person in or belonging to the fleet shall sleep upon his watch, or negligently perform the duty imposed on him, or forsake his station on pain of death ..." (Parkin, 1997).

While incidents at sea had life or death consequences for those 18th century seafarers, the contemporary situation is arguably more threatening. Dinges (1995) states that "... it is now possible for a fatigue related vigilance error of a single person working on the night shift and/or without adequate sleep to trigger an industrial accident that can kill thousands of people, damage major proportions of the environment and/or cost billions of dollars".

Accident reports describe a complex interrelationship between sleep, work and leisure existing among those involved in watchkeeping activities, however accident investigators are more able to assign watchkeeper's frank-sleep episodes as contributory to an accident than the more subtle deficiencies in cognition and judgement resulting from fragmented and deficient sleep.

Not all sleep is associated with the fatigue state. As will be detailed below, the routine on board coupled with the biological need for sleep infers that all crew members will sleep from time to time during the day, hopefully, but not always while off watch. At times, all crew members of fishing vessels with small crew numbers may be asleep without posting a watchkeeper. At other times, significant crew members, such as the master, the pilot or the skipper of a fishing vessel may be asleep, when ideally their presence on watch may avert some incident. A possible relationship between sleeping, fatigue and accidents is illustrated in Fig. 1.

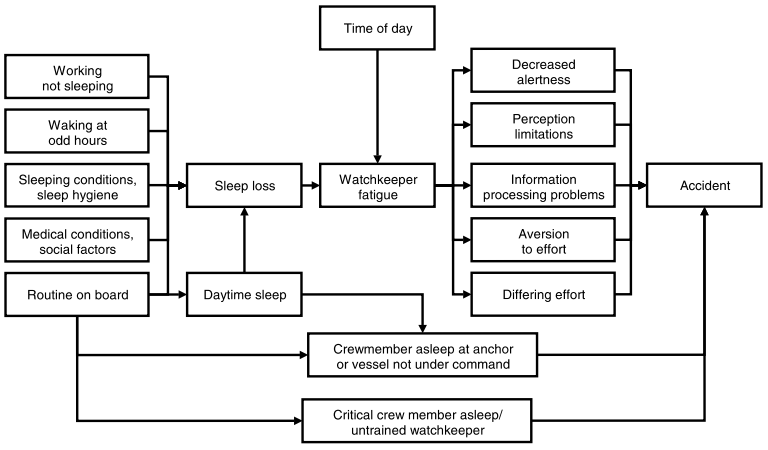

Fig. 1. Sleep loss, sleeping, fatigue and accidents.

Accident reports describe contributory factors such as long work periods, poor quality sleep, "jet-lag", broken sleep, self-inflicted sleep deprivation, disrupted sleep patterns and a poor sleeping environment. As the master, second mate and pilot were the primary contributors in two-thirds of all incidents, the routine and contribution of these particular watchkeepers could be considered in comparison to other watchkeepers.

4.2. The master

The master's involvement is reported across all watches and evenly distributed between collisions and groundings. Only in one incident, however, is the master's contribution associated with being sleep deprived (the tugmaster of the Wambiri suffering slight sleep debt) and in no instance is the master reported as being asleep while on watch. The relative lack of association of sleeping and sleepiness with accidents involving masters is remarkable given the master's overall responsibility for the safe operation of the vessel and the requirement to take command during critical manoeuvres. Many studies comment that neither prior experience with sleep loss nor perceived adaptation result in adjustment to sleep loss (e.g., Webb & Levy, 1982; Carskadon & Dement, 1981). It is unlikely, therefore, that the master has adjusted to working in a sleep deprived state, but rather is in an advantageous position to adapt his sleeping habits around the work routine. For example, the master of the Karin B (Incident no. 100) arranged a pilot boarding time to "allow him to get some sleep", and the master of the Columbus Victoria (Incident no. 102), "went to bed some time before 2200 ... anticipating an early call to weigh anchor". There are numerous references to masters getting some rest prior to berthing, anchoring or some demanding manoeuvre. Sanquist et al. (1997) report command personnel having the highest average sleep duration of all personnel in a field study of 141 marine personnel. Sanquist et al. (1997) also report lower levels of subjective decreased alertness among command personnel than other watchkeepers.

The master's responsibility for overall command as well as his ability to exert some control over his sleeping pattern may also lessen the impact of disrupted and deficient sleep. Haslam (1982) and Krueger (1989) report a greater deterioration in event-paced tasks than self-paced tasks. In addition, Krueger (1989) notes that following sleep deprivation, vigilance and detailed cognitive tasks deteriorate more rapidly than simple and well-learned tasks. The master's experience as well as a greater capacity to self-pace tasks may help mitigate against the effects of sleep deprivation.

4.3. The second mate

The second mate's contribution is mainly to collisions (six collisions compared to two groundings and one other incident) and incidents occurring during the second mate's watch (six incidents on the 0000 to 0400 watch, two on the 1200 to 1600 watch). Reference to the second mate either being asleep or sleep deprived is made in three incidents, the highest frequency of any individual contributor. The second mate being contributory is associated with the highest number of sleep references (44% of all sleep references) and the second highest number of incidents, yet the literature suggests that the second officer's watch allows longer sleep time than the average for watchkeepers (Rutenfranz et al., 1988; Sanquist et al., 1997). In contrast, however, Sanquist et al.

(1997) report the second officer's watch as having significantly more work periods with critically low alertness levels than personnel on other watches.

Rutenfranz et al. (1988) note that the second officer typically has two equal sleep periods commencing about 0500 and 1900. Sanquist et al. (1997) report a similar pattern. Though the second mate's average sleep duration is reported to be longer, sleep commencing in the morning is shown to be less beneficial than sleep commencing in the afternoon (Naitoh, 1981). Åkerstedt (1995b) also reports a circadian influence resulting in short morning sleeps. In addition, the early evening time of sleep resistance reported by Lavie (1988) as the "forbidden zone" for sleep corresponds to the approximate starting time for the second mate's evening sleep. Finally, Stepanski, Lamphere, Badia, Zorick, and Roth (1984), and Carskadon, Brown, and Dement (1982) note the relationship between sleep fragmentation and daytime sleepiness. It appears that though the second mate enjoys greater than average sleep duration, the split sleep periods occur at the least efficient times of the day for sufficient restorative value.

The majority of behaviours associated with incidents occurring on the second mate's 0000 to 0400 watch are associated with decreased alertness (Phillips, 1998). This is consistent with Monk and Embury (1981) findings that perceptual and sensomotor errors predominate following sleep deprivation, but less errors are found at night in complex monitoring and control tasks. The sleep-deprived and fatigued second mate simply loses alertness and his vessel runs aground, or more likely collides with another vessel.

Most collisions reported in this study involve commercial vessels and fishing boats. Fishing boat manning levels frequently lead to unsafe practices such not posting an anchor watch or posting an unqualified watchkeeper (such as the cook). Five of the eight collisions where either the fishing boat skipper and/or crew were asleep occurred on the second mate's 0000 to 0400 watch. Accident investigators usually find that a combination of the second mate's decreased vigilance (possibly from sleep deprivation) and inappropriate or absent watchkeeping (possibly due to being asleep) on board fishing vessels is a common cause of collisions.

4.4. The pilot

The pilot was associated with seven groundings and one collision, predominantly on the 0400 to 0800 watch. This distribution is not surprising, given the coastal nature of pilotage. In seven of the eight incidents, accident investigators describe various errors of judgement, disorientation or failure to appraise a situation. In only one incident was sleep a contributory factor, the pilot of the Peacock (Incident no. 95) losing situational awareness, in all probability by falling asleep. This incident occurred on the 0000 to 0400 watch, consistent with most other instances of watchkeepers falling asleep on watch.

The role of the marine pilot is substantially different from that of others involved in watchkeeping. Pilotage involves complex issue of port-state sovereignty, and the use of local knowledge and judgement by the pilot in navigating coastal waters. Carpenter and Huffner (1977) describe the retrieval of information stored in the pilot's long term memory as he scans information sources in the environment in a repetitive manner, with experienced pilots being able to anticipate situations well in advance before they become critical. It is therefore not surprising that incidents involving pilots are associated with failure of higher level cognitive processes, rather than a decrease in alertness.

There is considerable literature linking sleep deprivation with decreased vigilance and alertness (e.g. Åkerstedt, 1995b; Bonnet & Arand, 1995; Wilkinson, Edwards, & Haines, 1966); however, the pilot's role is more complex than just maintaining alertness. De Vries-Griever and Meijman (1987) note that performance in complex tasks that utilise high memory load (such as that of pilots) gets worse in the course of the day, whereas performance on tasks utilising low memory load seem to improve in the course of the day. Krueger (1989) notes that both vigilance and more detailed cognitive tasks deteriorated most in 90 h of sleep deprivation and 4 h sleep per day for 6 days (the latter resembling marine pilots average sleep), simple and well-learned tasks deteriorating little. Similarly, Haslam (1982) reports a deterioration of cognitive function and logical reasoning following one night without sleep. Parker and Hubinger (1998) describe decreased sleep time (an average of 0.59 h per 24 h in the Great North East Channel pilots) and fragmented sleep (an average over three sleep periods per 24 h period on the Great Barrier Reef Inner Route), with pilots accumulating a daily sleep debt of 5.6–6 h. Sleep latency and sleep efficiency data in Parker and Hubinger (1998) was consistent with pilots being in a fatigued state.

4.5. Other watchkeepers

The first and third mate are only associated with six incidents, with only one incident each associated with sleeping. The first mate of the Carola (Incident no. 79) fell asleep due to fatigue during his 0400 to 0800 watch, while the master and the pilot were asleep off-watch. The first mate was described as a conscientious and keen officer, but following an intake of alcohol and a shorter than normal prior sleep, he probably fell asleep a little after 0430 during the circadian low. This incident illustrates the extreme sleepiness as described by Åkerstedt (1995a) due to the interrelationship between working during the circadian low, extended work hour and reduced sleep length. The compounding effect of alcohol would have also exacerbated the first mate's sleepiness.

The third mate of the Eternal Wind (Incident no. 131) failed to maintain an effective lookout (he was working out compass error while the seaman-lookout was working on deck). At 0815 the Eternal Wind collided with the fishing boat Melinda T. The watchkeeping deckhand noticed the Eternal Wind only seconds before the collision. The skipper of the Melinda T routinely slept in the wheelhouse in order to be immediately available, 3-h watches being maintained by the deckhands. During the voyage, the vessel experienced 20–25 knot winds and 2–2.5 m seas, with the vessel yawing through 20°. Though sleep deprivation was not identified by accident investigators, the need for daytime sleep by Melinda T's off-watch and the disagreeable sleeping environment for the skipper illustrates a number of sleep hygiene factors associated with fishing vessels. Torsvall and Åkerstedt (1988) note that on-call conditions shorten sleep duration and sleep quality, with an increased sleepiness on the following day. The need to be readily available, in conjunction with the compounding effects of noise and motion on board a fishing vessel at sea may have adversely affected the skipper's sleep. There has been little sustained research on the effects of the physical environment other than noise and heat (Hockey, 1986). Parker and Hubinger (1998) study of the work and rest patterns of Great Barrier Reef pilots found that it was unlikely that sleep at sea was affected to any degree by sea conditions.

5. Conclusions

While no rigorous causal link can be established between the watchkeeping environment, sleepiness and accidents, this analysis shows that Incident at Sea Reports are a rich source of descriptive data showing a high level of association of sleeping and sleepiness with accidents. Thirty nine percent of Incident at Sea Reports describe sleeping or sleepiness as contributory to an accident. The Incident at Sea Reports also paint a picture of the truncated and fragmented sleep of watchkeepers, critical fatigue behaviours, and occasionally the unfavourable sleeping environment found on board fishing vessels.

The nature and distribution of the accident investigator's references to sleep compared to the incident type and watchkeeping period allowed some analysis of the contributing factors of sleepiness between key crew members. Ship masters rarely exhibit sleepiness, but appear to have well-developed strategies for coping in a sleep-depriving environment. Second mates, however, suffer a greater frequency of decreased alertness than other officers, possibly due to their watch times and sleep times. Marine pilots may be the most sleep-deprived of all watchkeepers, but rarely suffer loss of alertness. The pilot's contribution to accidents is in the form of errors of judgement and disorientation. First and third mates are rarely associated with incidents at sea. There is considerable scope for further work to establish the relationship between the tasks, sleep opportunities and circadian factors affecting the performance of the various officers involved in watchkeeping.

Though accident investigators may experience difficulty retrospectively analysing the contribution of sleep loss to behavioural manifestations of fatigue other than decreased alertness, the investigation process should continue to consider the effect of sleep deprivation and time of day on errors involving judgement, reasoning and higher level cognitive functions.

Finally, the unique nature of watchkeeping and seafaring demands that further industry-specific research should be undertaken to identify and quantify the manifestations of fatigue other than that of decreased alertness.

References

Åkerstedt, T. (1995a). Work hours, sleepiness and accidents: introduction and summary. *Journal of Sleep Research*, *4*(Suppl 2), 1–3.

Åkerstedt, T. (1995b). Work hours, sleepiness and the underlying mechanism. *Journal of Sleep Research*, *4*(Suppl 2), 15–22.

Berger, Y. (1984). *Port phillip sea pilots: an occupation at risk*. Department of Psychology and Brain Behaviour Research Institute: La Trobe University.

Bonnet, M. H., & Arand, D. L. (1995). We are chronically sleep deprived. *Sleep*, *18*(10), 908–911.

Carpenter, M. H., & Huffner, J. R. (1977). Pilot decision making while maneuvering in confined waters. In D. Anderson, H. Istance, & J. Speer (Eds.), *Human factors in the design and operation of ships* (pp. 450–462). Organising Committee of the First International Conference on Human Factors in the Design and Operation of Ships.

Carskadon, M. A., Brown, E., & Dement, W. C. (1982). Sleep fragmentation in the elderly: relationship to daytime sleep tendency. *Neurobiology of Aging*, *3*, 321–327.

Carskadon, M. A., & Dement, W. C. (1981). Cumulative effects of sleep restriction on daytime sleepiness. *Psychophysiology*, *18*(2), 107–113.

Cook, T. C., & Shipley, P. (1980). Human factors studies of the working hours of UK ships pilots, 1. A field study of fatigue. *Applied Ergonomics*, *11*(2), 85–92.

De Vries-Griever, A. H. G., & Meijman, T. F. (1987). The impact of abnormal hours of work on various modes of information processing: a process model on human costs of performance. *Ergonomics*, *30*(9), 1287–1299.

Dinges, D. F. (1995). An overview of sleepiness and accidents. *Journal of Sleep Research*, *4*(Suppl 2), 4–14.

Filor, K. (1996). The original twenty-four hour society: issues of fatigue and incidents at sea. In *Proceedings of the Second International Conference on Fatigue and Transportation*, Fremantle, Australia, 11–16 February 1996.

Haslam, D. R. (1982). Sleep loss, recovery sleep and military performance. *Ergonomics*, *25*(2), 163–178.

Hockey, G. R. (1986). Changes in operator efficiency as a function of environmental stress, fatigue and circadian rhythms. In K. Boff, L. Kaufman, & J. P. Thomas (Eds.), *Handbook of Perception and Human Performance* (Chapter 44, pp. 1–49). New York: Wiley.

Krueger, G. P. (1989). Sustained work, fatigue, sleep loss and performance: a review of the issues. *Work and Stress*, *3*(2), 129–141.

Lavie, P. (1988). Twenty-four hour patterns of sleep propensity. In A. Coblentz (Ed.), *Vigilance and Performance in Automated Systems*. Dordrecht: Kluwer Academic Publishers.

Monk, T. H., & Embury, D. E. (1981). A field study of circadian rhythms in actual and interpolated task performance. In A. Reinberg et al. (Eds.), *Night and Shiftwork. Biologocal and Social Aspects* (pp. 473–480). Oxford: Pergamon Press.

Naitoh, P. (1981). Circadian cycles and restorative power of naps. In L. C. Johnson, D. I. Tepas, W. P. Colquhoun & M. J. Colligan (Eds.), *Variations in Work-Sleep Schedules: Effects on Health and Performance. Advances in Sleep Research*, Vol. 7. (pp. 553–580). New York: Spectrum Press.

National Competency Standards for the Maritime Industry. (1993). National Maritime Industry Training Council Inc.

Parker, A. W., & Hubinger, L. (1998). On tour analysis of the work and rest patterns of great barrier reef pilots: implications for fatigue management. Australian Maritime Safety Authority: Canberra. Available: http://www.amsa.gov.au/sp/fatigue.

Parkin, R. (1997). *H. M. Bark Endeavour* (p. 105). Melbourne: Melbourne University Press.

Phillips, R. (1998). Fatigue among ship's watchkeepers: a qualitative study of incident at sea reports. In L. Hartley (Ed.), *Managing Fatigue in Transportation* (pp. 315–337). Oxford: Elsevier.

Richards, T., & Richards, L. (1994). Using computers in qualitative research. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 445–462). Thousand Oaks: Sage.

Rutenfranz, J., Plett, R., Knauth, P., Condon, R., DeVol, D., Fletcher, N., Eickhoff, S., Schmidt, K. H., Donis, R., & Colquhoun, W. P. (1988). Work at sea: a study of sleep, and of circadian rhythms in physiological and psychological functions in watchkeepers on merchant vessels; Part VI – A sea trial of an alternative watchkeeping system for the merchent marine. *International Archives of Occupational and Environmental Health*, *60*, 331–339.

Sanquist, T., Raby, M., Forsythe, A., & Carvalhais, A. (1997). Work hours, sleep patterns and fatigue among merchant marine personnel. *Journal of Sleep Research*, *6*, 245–251.

Stepanski, E., Lamphere, J., Badia, P., Zorick, F., & Roth, T. (1984). Sleep fragmentation and daytime sleepiness. *Sleep*, *7*(1), 18–26.

Torsvall, L., & Åkerstedt, T. (1988). Disturbed sleep while being on call: an EEG study of ships engineers. *Sleep*, *11*(1), 39–46.

Webb, W. B., & Levy, C. M. (1982). Age sleep deprivation and performance. *Psychophysiology*, *19*, 272–276.

Weitzman, E. A., & Miles, M. B. (1995). *Computer Programs for Qualitative Data Analysis*. Thousand Oaks: Sage.

Wilkinson, R. T., Edwards, R. S., & Haines, E. (1966). Performance following a night of reduced sleep. *Psychonomic Science*, *5*, 471–472.