On Tour analyses of the work and rest patterns of Great Barrier Reef pilots: implications for fatigue management

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Summary of Results

This investigation represents the final phase of a comprehensive research program designed to investigate the contributing factors to fatigue in the work practices of Great Barrier Reef (GBR) pilots. In this study information related to both general and specific aspects of the work and rest periods was recorded by pilots in specially designed logbooks. The information evaluated focused on factors which have the potential to produce fatigue and decrements in performance and included the timing and quality of sleep during assignments at sea and during rest breaks, and estimates of fluctuations in alertness during work on the bridge. Additional work specific factors which may increase the difficulty of an assignment and have a bearing on fatigue were also assessed. These included the weather, ship handling and under keel clearance, bridge team skill levels and accommodation and meals.

Specific patterns of sleep at sea and ashore that have the potential to reduce the recuperative value of sleep such as duration and timing across the 24 hour cycle, and the percentage of sleep during optimal physiological sleeping hours (2200-0800) were also examined.

The results are based on an analysis of 176 work assignments undertaken on 3 shipping routes by 23 GBR pilots during the months of May and June, 1998. In general the results identified a range of work/rest, alertness, personal and environmental factors that potentiate or predispose pilots to fatigue.

Overview of Work Assignments

Work assignments involve a continuous period of time spent by pilots onboard vessels: assignment duration is adjusted for travel to and from the ship. In the Barrier Reef region pilotage work involves pilots alternating between work assignments on the ship and time ashore during assignment breaks. This section provides an overview of work assignments in terms of the duration, starting times and the amount of time spent on pilotage duties. Additionally, the degree of contribution to work assignment stress and/or fatigue from pilotage specific factors was examined.

Inner Route assignments averaged 54 hours compared with 14 and 16 hours for pilotages on the GNE Channel and Hydrographers Passage, respectively.

Ninety-five percent of time on board ship was spent on pilotage duties on the Inner Route and GNE Channel, compared with 66 percent on Hydrographers Passage assignments. Pilotage duties are defined as duties undertaken during the time between beginning and ceasing pilotage and cover bridgework and rest periods.

During Inner Route and GNE Channel passages, the percentage of time spent on pilotage duties resulted in a ratio of pilotage time to non pilotage time of 19:1. On Hydrographers Passage assignments this ratio was 2:1.

During a tour (period of time during which a number of individual work assignments are completed) onboard time accounts for 43 percent of the tour time with 57 percent being ashore time, thus the onboard to ashore ratio was1:1.32.

The irregularity of pilotage work was confirmed by the rectangular distribution of assignment and break starting times across the 24 hour cycle on all shipping routes.

Inner Route and GNE Channel assignments were rated more fatiguing than work on Hydrographers Passage.

Difficulties associated with weather conditions, visibility, ship handling and under keel clearance, bridge team skill levels, meals and accommodation were perceived by pilots to be more problematic on the Inner Route and GNE Channel.

Travel to and from ships was the highest rated of the factors contributing to work assignment stress and fatigue on the three shipping routes.

Bridgework

While the previous work schedule analysis provided details of the duration of work and rest periods, the logbook data provided an opportunity to record specific details of bridgework (defined as time on the bridge). These included details of bridgework such as the duration, timing and the percent undertaken at night and during critical hours which are summarised below.

During an assignment, the mean duration of bridge periods totalled 21 hours on the Inner Route and 7 and 9 hours for Hydrographers Passage and the GNE Channel, respectively.

On Inner Route assignments, bridge periods averaged 3 hours and were undertaken during 7 separate periods. Whereas on other shipping routes bridge periods averaged 6.6 hours and were conducted during a single bridge period.

For GNE Channel and Hydrographers Passage assignments, 98 percent and 86 percent of pilotage time (defined as the time between commencing and ceasing pilotage duties during an assignment) was spent on the bridge. In contrast, 51 percent of pilotage time was spent on the bridge on the longer Inner Route.

On the three shipping routes, the percentage of bridge time at night, that is, between 1818 - 0525 hrs, was similar: Inner Route, 46 percent; Hydrographers Passage, 37 percent; and GNE Channel, 52 percent.

Across the three shipping routes, approximately 30 percent of bridge times were undertaken during critical hours (2300-0600), which has been shown to be associated with reduced alertness and increased accident risk.

During the sampling period, sea conditions during bridge periods were predominantly medium on the GNE Channel and calm/medium on the other two routes.

Sleep at Sea

During pilotage work, sleep at sea is usually taken during the less difficult navigational sections of the route where pilots consider the ships progress can be safely monitored by the bridge team. Information on the duration, quality and timing of sleep during an assignment was recorded by pilots and analysed to identify any differences between the 3 shipping routes. The results of these analyses are provided below.

During assignments total sleep time per 24 hours averaged 0.6 hours on the GNE Channel and 4 and 5 hours on Hydrographers Passage and the Inner Route, respectively.

During Inner Route assignments the 5 hours of sleep per 24 hours was undertaken in approximately two, 2.5-hour periods. In contrast, on Hydrographers Passage and GNE Channel pilotages, average daily sleep was taken during a single period. Pilots reported losing between 2 and 3 minutes of sleep due to awakenings.

Sleep latency (time to fall asleep) ranged between 4 and 7 minutes at sea and was within or close to sleep latency periods associated with a fatigued state (latency < 5 minutes). Fatigue is considered a general response to various forms of stress resulting in performance decrements.

The percentage of sleep with latencies < 5 minutes was: 32 percent on Hydrographers Passage, 39 percent on the Inner Route and 83 percent on the GNE Channel.

Sleep efficiency (percent of time in bed spent sleeping) ranged between 90 and 93 percent and indicated pilots were exhausted, and slept with very few interruptions despite sub-optimal sleeping accommodation in some instances.

Sleep quality was similar on all three shipping routes, with scores of between 19 to 21, towards the higher end of the scale (range 5-25) and similar to ratings of sleep quality reported by mariners involved in day work.

The percent of sleep taken during the optimal hours of 2200-0800 differed according to the shipping route. On Hydrographers Passage, 81 percent of sleep was within this time, whereas 50 and 60 percent of sleep was between these hours on the Inner Route and GNE Channel, respectively. Thus, between 40 and 50 percent of sleep was outside optimal sleeping times for the Inner Route and GNE Channel.

Daily sleep debt (difference between sleep duration ashore and at sea) averaged 5.7 hours for the Inner Route and was more problematic on this route given the 55 hour assignment duration in this region.

During sleep periods predominantly calm sea conditions were experienced on Hydrographers Passage. For the Inner Route calm or medium conditions prevailed during 50 percent of sleep periods; in contrast on GNE Channel assignments sea conditions were principally medium.

Sleep ashore

Breaks between assignments provide an opportunity for pilots to recuperate and prepare for the next assignment. Depending on the distance between the point of embarkation and the pilot's home base, pilots spend their break in company accommodation or at home. An assessment of sleep patterns during breaks ashore provided an insight into the recuperative value of these periods.

Thirty-three percent of breaks were spent in pilot accommodation, and others spent at home (28 percent) and in hotels/motels (30 percent), with around 10 percent in other types of accommodation.

Average break duration before assignments ranged from 36 hours for Hydrographers Passage to 60 and 72 hours for GNE Channel and Inner Route passages, respectively.

Between 5 and 10 percent of assignment breaks did not comply with current guidelines for break duration.

Total sleep time per 24 hours before assignments on the Inner Route, Hydrographers Passage and GNE Channel was 11, 10 and 9 hours, respectively.

Prior to assignments on each shipping route, sleep ashore approximated conventional patterns; that is, sleep was mostly taken in one sleep period averaging 7 hours plus an additional shorter period of 2-3 hours.

Pilots averaged between 5 and 8 minutes to fall asleep ashore, with 39 percent of sleep periods displaying latencies of less than 5 minutes.

While sleeping ashore pilots lost between 5 and 7 minutes due to awakenings, and reported taking between 9 and 17 minutes to feel alert.

Approximately 20-30 percent of sleep began outside the optimal sleeping hours (2200-0800). This finding indicates that break duration and/or timing prevented sleep being taken during optimal hours during a number of breaks.

Sleep quality ashore was rated relatively high, with scores between 19-22 similar to sleep quality ratings at sea. Thus, relatively high ratings of sleep quality applied to the longer duration sleep ashore and the shorter sleep at sea.

Measures of Alertness and Fatigue during bridge periods

Alertness fluctuations and the presence of fatigue symptoms during bridgework have been associated with decreased performance and increased accident risk. A summary of alertness ratings and the presence of fatigue symptoms during bridge periods are presented below.

Pilots average alertness ratings during bridge periods ranged between 6.1 and 7.7 and were towards the upper end of the rating scale (scale 1-9). There were no significant differences in alertness ratings during bridgework across the shipping routes or changes across time.

The percentage of bridge periods with alertness ratings < 3 (indicating sleepiness) ranged from 3 percent on Hydrographers Passage to 8 and 12 percent on the Inner Route and GNE Channel, respectively.

The number and frequency of fatigue symptoms was significantly greater for bridge periods on the Inner Route and GNE Channel assignments compared with Hydrographers Passage. This finding is consistent with a reduction in the degree of difficulty associated with pilotage work on Hydrographers Passage.

The percentage of bridge periods exhibiting one or more symptoms of fatigue ranged from 58 percent for the Inner Route and Hydrographers Passage to 83 percent for GNE Channel work assignments.

The presence of acute fatigue was identified by the considerable proportion of sleep episodes with latencies of less than 5 minutes and some bridge periods with minimum alertness.

Factors associated with high fatigue levels and low alertness levels on the bridge

Results from the analysis of logbooks and other data sources, particularly the work schedules (Parker et al., Report No 2, 1998) indicated the presence of several key measures associated with decreased alertness and increased fatigue. In light of these findings, a series of multiple linear regression models were used to assess contributions to variation in mean overall fatigue, stress, and minimum alertness measures of pilot data reflecting ashore and at-sea variables.

- Over 90 percent of the variation in the three outcome variables of fatigue, stress and alertness was accounted for by individual differences in pilots and total break and work assignment duration.
- More specifically, modelling procedures indicated that break duration contributed relatively more to alertness than to fatigue and stress. In contrast, assignment duration contributed relatively more to fatigue and stress than to alertness. Although the contribution was small, results suggested that the total duration of bridge periods per assignment contributed relatively more to alertness than to fatigue or stress.
- Results of the modelling procedures indicated that if additional data were collected to enhance the present reporting system for evaluating fatigue, stress and alertness on the bridge it should consider both the total duration of bridge periods and duration during critical hours and travel to and from the ship.

Summary

Overall, the findings have indicated a presence of, and/or potential for, fatigue in the work practices of GBR pilots. The strong statistical evidence of a shipping route effect on characteristics of work assignments, bridgework and sleep at sea highlighted the different level of demands from work patterns on the three shipping routes. In addition, ship characteristics and environmental factors were more problematic on the Inner Route and GNE Channel pilotages, whereas travel impacted similarly on assignment stress and/or fatigue on all shipping routes.

The intensive nature of pilotage work at sea was reflected in the large percentage of work assignment time spent on pilotage duties. Pilots rated their average alertness during bridgework as quite high. This was surprising considering that a significant proportion of bridgework was undertaken during night and early morning hours. Moreover, up to 12 percent of bridge periods displayed alertness ratings indicating sleepiness, and a number of fatigue symptoms were experienced during bridgework on the Inner Route and GNE Channel.

Preliminary results of statistical modelling procedures highlighted the need to include data on work assignment and break duration, the total duration of bridge periods, bridge time during critical hours and work-related travel when evaluating the potential for fatigue, stress and alertness on the bridge.

Sleep at sea was short and mostly fragmented. Sleeping patterns at sea were interspersed by sleep ashore which approached more conventional sleeping habits in terms of the duration during a single sleep period. That a considerable percentage of sleep in both locations was outside optimal sleeping hours raised questions over the recuperative value of the sleep at sea and ashore. Several characteristics of sleep in both locations displayed a heightened potential for fatigue. For instance, the relatively high percentage of sleep with short sleep latencies and high sleep efficiency suggested a fatigued state.

That sleep quality was rated high at sea and ashore suggests that pilots sleep was recuperative, however, based on previous evidence from the same group, the high rating in both locations also suggested that sleep quality may have been slightly overrated by respondents. Given the considerable number of measures associated with work and sleep periods the possible over rating of these measures is unlikely to impact on the overall findings.

In summary, the findings from this investigation support those from earlier phases of the research program and indicate the presence of several critical factors associated with the work practices of GBR pilots which have the potential to contribute to both acute and chronic fatigue. When considered in the context of evidence of a significant relationship between fatigue and vessel and personal accidents which exists in the research literature, this information highlights the inadequacies of the current system used by AMSA and the pilot companies to monitor fatigue and the lack of any fatigue management program. In this respect, all groups responsible for the delivery of pilotage services in this most sensitive region are highly vulnerable to the consequences of fatigue, including decreased performance and increased accident risk. Consequently, the findings from this research have been used as the basis for the recommendations in this report which are designed to enhance existing work practices in the context of fatigue reduction through appropriate fatigue management strategies.

Rationale for Recommendations

Evidence of the high potential for fatigue associated with the work practices of GBR pilots was found in our retrospective analysis of the work schedules of the pilots and from log book entries concerned with the duration, nature and impact of work at sea and time ashore on measures of alertness. The retrospective analysis included work and rest times associated with 4310 assignments reported by the pilots over an 18 month period. The more detailed analysis of the log book information was based on 176 assignments and associated rest periods. General aspects of the work practices that were conducive to fatigue included the time on and off the ship, specific aspects of bridge work, and the characteristics of sleep at sea, and sleep ashore during breaks. Other factors identified from the various phases of the analysis which have been shown to impact on fatigue included:

- irregular timing of work and rest periods across the 24 hour cycle, which displaced work and sleep from usual circadian patterns;
- increased workload due to work-related travel;
- instances where considerably greater workloads and shorter rest breaks were experienced by pilots, compared with average company figures;
- significant increases in work availability during particular time periods (July - Dec);
- significant company differences in workload levels;
- significant shipping route differences in assignment difficulty;
- long bridge periods;

- a considerable percentage of bridge periods at night and during critical early morning hours associated with increased accident risk;
- short and fragmented sleep at sea with a considerable percentage outside optimal sleeping hours;
- the daily sleep debt at sea being more problematic on the longer shipping route;
- a considerable percentage of sleep ashore outside optimal sleeping hours; and
- the presence of acute fatigue identified by alertness ratings during bridge periods indicating sleepiness, and sleep periods with short sleep latencies suggestive of considerable tiredness.

Fatigue is associated with performance impairment (Dinges,1992; Dinges & Kribbs,1991; Rosekind et al.,1996) and contributes to a significant number of marine incidents (Japan Maritime Research Institute,1993; McCallum et al.,1996; Sanquist et al.,1996; Filor, 1998). It is therefore, essential that careful consideration be given to strategies for preventing the development of fatigue in a safety-based industry.

At present, monitoring of fatigue in GBR pilots is primarily achieved by reviewing compliance with minimum rest break guidelines and subjectively assessing prior workloads across a tour of duty. However, the presence of a range of factors identified in the various phases of this research that potentiate or predispose pilots to fatigue indicates the inadequacy of these guidelines. Moreover, statistical modelling indicated that the prediction of fatigue, stress and alertness on the bridge could be enhanced by considering data on total work assignment and break duration, the total duration of bridge periods and bridge time during critical hours and work-related travel.

In consideration of the development of additional fatigue management strategies it is important to consider:

- the need for adequate recovery following specific work assignments; and
- the need to improve fatigue monitoring practices.

Optimal recovery time ashore is particularly important given that pilotage work at sea is intense with extended periods of work on the bridge and a significant proportion of this work undertaken during night and early morning hours. Additionally, the reduced duration and quality of sleep at sea particularly on the Inner Route suggested sleep patterns at sea likely magnified the impact of bridge work. These conditions coupled with the requirement to sustain vigilance over long periods in a relatively monotonous environment are conducive to fatigue. Research findings have shown that following a period of restricted sleep, at least two nights of recovery sleep (taken during normal physiological sleeping times) are required before complete recovery is achieved (Dinges et al.,1997; Morris & Miller,1996; Transportation Safety Board of Canada,1997; Wittersheim et al.,1992). Furthermore, there were a number of instances identified from the log book and work schedule analysis when rest breaks failed to meet current regulations, thereby further limiting the opportunity for recovery and increasing the risk of fatigue development and accident.

The current investigation revealed that a considerable percentage of sleep ashore was displaced from normal sleeping hours due to the starting time and duration of the break. Studies have shown that sleep outside optimal sleeping hours tends to be of reduced duration and of inferior recuperative value (Akerstedt, 1995; Folkard, 1996; Kecklund et al., 1997; Transportation Safety Board of Canada, 1997). As a consequence of both these factors (circadian dissociation and displaced sleep), a sub-optimal psychophysiological state may be induced (de Vries-Griever & Meijman, 1997). This, in turn may result in increased fatigue, mood deterioration and performance decrements (Condon et al., 1988; Luna, 1997; Monk, 1989; Monk & Folkard, 1992: Rosekind et al., 1996). Hence, it is vital that the timing of work and rest is considered when addressing fatigue.

The present analysis also showed an even distribution of rest breaks and work periods across all time periods of the 24 hour cycle; thereby indicating rest breaks and work periods are likely to start at any point within a 24 hour day. Current rest break regulations fail to take into consideration the timing of work and rest across the 24 hour cycle and the impact of this on recovery periods ashore.

Irregular work hours place additional strain on workers, as in such situations, people oppose the normal diurnal nature of the human body by attempting to maintain high levels of alertness when their body is anticipating sleep, and by trying to sleep when alertness and arousal are naturally increasing. This, in turn creates disharmony between a person's circadian rhythms and the normal social and environmental time cues, thereby leading to circadian dissociation (Griffiths, 1993; Luna, 1997; Rosekind et al., 1996; Scott & Ladou, 1990). While pilots may argue that after long years of general maritime and pilotage service they have adapted to irregular work and sleep, the literature indicates there is little, if any, circadian adaptation to work schedules involving frequent changes of work times (Colquhoun, 1985; Costa, 1993; Luna, 1997; Monk & Folkard, 1992).

Moreover, increasing age, poor health and physical fitness reduce tolerance for irregular work (Folkard, 1996; Harma, 1993; Monk & Folkard, 1992). The relatively older average age of the present pilot group (52.6 years) and the evidence of compromised health as well as lifestyle habits (Parker et al., 1997; Parker et al., Report No 4, 1998) indicate these factors need to be considered when assessing the impact of irregular work and appropriate recovery periods.

The present findings suggest the need to modify existing reporting systems to include additional information related to fatigue and to provide a monitoring system which is more proactive. The current system of reporting includes information limited to work and break times and provides little opportunity for intervention should a situation of potential acute or chronic fatigue arise.

Recommendations

Given that marine pilotage work is dependent on shipping demands and that the maritime industry operates on a 24 hour basis, some of the potential fatigue factors associated with pilotage work patterns are unchangeable. For example, starting times of work assignments and rest breaks, night work and assignment duration cannot be altered. However, there are a number of areas which are amenable to intervention and hence, the recommendations have focused on these areas.

The recommendations are made with the aim of reducing the risk of developing a level of fatigue which may impair the work performance of GBR pilots, compromise personal health and increase the risk of accidents. While these recommendations may, at times, be at variance with commercial interests, it is anticipated that any modification of fatigue management procedures will be implemented following close collaboration between the various parties.

The areas targeted by the recommendations include the development of strategies designed to:

- implement rest break guidelines which minimise fatigue potential;
- develop a more systematic method of work allocation to maintain compliance with rest break guidelines;
- enhance monitoring of rest breaks and work allocation at official levels;
- enhance the accident/incident reporting procedures with respect to fatigue;
- provide adequate educational programs and greater personal responsibility for the management of fatigue;
- enhance the medical monitoring of pilots in terms of risk of fatigue-related problems; and
- provide adequate educational programs on health and lifestyle issues including stress management.

Recommendation 1: Reassessment of present guidelines for minimum rest breaks between work assignments and develop guidelines which will minimise fatigue potential.

To avoid the development of fatigue, there needs to be sufficient time between work periods to enable pilots to completely recover from fatigue due to previous work demands. Guidelines need to consider factors contributing to pilot fatigue, contemporary knowledge in the area of work, rest and recovery, and the standards set by international transportation research relating to recovery periods.

Findings from this research provides considerable evidence which questions the adequacy of present break guidelines:

- Logbook and work schedule findings revealed that 30-40 percent of sleep ashore was currently outside optimal sleeping hours (2200-0800) and thus its recuperative value may be considerably diminished.
- Exploratory modelling procedures indicated that the duration of the break preceding an assignment contributed to a considerable degree to alertness during bridgework.
- Current minimum rest break guidelines for Great Barrier Reef pilotage address basic differences in shipping route duration (i.e. more extensive breaks are required prior to work on the longer Inner Route) (AMSA, 1997). However, current guidelines do not consider break starting times which determine the duration and recuperative value of sleep during time ashore.
- Study results raised questions over the appropriateness of similar duration rest breaks prior to work on the GNE Channel and Hydrographers Passage shipping routes. There was considerable statistical evidence in the project indicating pilotage work in the GNE Channel region was more demanding despite the similar duration of assignments on both shipping routes.
- Factors such as shipping route conditions, the duration of work assignments (including transit times), the physical and mental demands of the work and the timing of work and rest in relation to the 24 hour cycle should all be considered in the development of work rest guidelines(States/BC OSTF, 1997).

In reviewing and developing break duration guidelines the following approaches should be considered:

- Breaks should provide the opportunity for two full nights of uninterrupted recovery sleep during optimal hours (2200-0800). Differences in shipping route duration and difficulty should also be taken into account when considering break duration guidelines and opportunities for recovery sleep
- To enable two full nights of uninterrupted recovery sleep during optimal hours (2200-0800) a minimum of approximately 34 hours break (for a break starting at 2200) and a maximum of about 50 hours (for a break starting at 0600) would be required. Presently, about 40-50 percent of current breaks provide the opportunity for two full nights or more of recovery sleep.
- The wording of guidelines should be specific rather than general. Currently, the wording of rest break guidelines is very general and does not specify hours or timing of sleep or even where the break should be taken (i.e. ashore). For example, guidelines should be worded more specifically: "following a work assignment, x sleep periods of at least y uninterrupted hours during optimal sleeping hours (i.e. between 2200 and 0800) while ashore are required".
- AMSA and pilot companies should jointly work towards the development of appropriate and workable break guidelines. Finalised guidelines should be endorsed by an expert panel.
- The development of strategies to deal with extenuating circumstances in situations where it is not possible for pilots to comply with guidelines. For example, upon completion of the next work assignment, an extended rest break to provide optimal sleep should then be made available.
- A predictive model for 'probable fatigue status' of the pilot should be developed. Such a model should be based on a number of calculated variables identified in the study findings and these include: (i) the number of previous assignments within the tour; (ii) present assignment duration; (iii) present rest break duration; (iv) shipping route characteristics; and (v) amount of night work undertaken during the present tour. It may be possible to monitor 'probable fatigue status' by way of a cumulative assessment following each work and rest period; factors increasing fatigue could be assigned a negative score, whereas factors reducing fatigue could be assigned positive values.
- The development of a predictive model to assess the recuperative value of sleep periods ashore. This model should consider the duration and timing of sleep in relation to the 24 hour cycle.

Recommendation 2: Implementation of revised guidelines – self regulation with minimum prescription.

Factors contributing to fatigue and its consequences in transportation have been debated internationally and nationally for many years. These discussions have cast doubt over the notion that highly prescriptive work hours are effective in reducing fatigue and fatigue related accidents (Moore, 1998). Moreover, economic pressure in transportation poses a considerable challenge to compliance with strict regulatory procedures. Strategies involving fatigue management plans have been implemented in a move away from strict prescription. However, while some sectors of the road and rail transportation industry in New Zealand and Australia have embraced fatigue management plans (Gander et al., 1998; McDonnell & Featherstone, 1998), it is fully acknowledged that these alone are not the answer to fatigue problems. More recent approaches to the hours of work and fatigue have involved a combination of minimum prescription with self regulation (Haworth, 1998).

An overview of a suggested approach to the implementation and review of guidelines is shown in Figure 1.0. In addressing the implementation of revised break guidelines the following approaches should be considered:

- Guidelines should involve minimum prescription and be based on study findings and refined through consultation between regulators, companies and pilots. Minimum prescription should be combined with appropriate self-regulation through formal fatigue management programs targeting both companies and individuals.
- Fatigue management programs/strategies at company and pilot level would require full documentation and audits at regular intervals.
- The demonstration by each company of work allocation in line with prescriptive break guidelines.
- Guideline monitoring should be carried out by AMSA in consultation with an appointed expert panel.
- In cases where certain prescriptive guidelines were considered extremely limiting, companies could request a change, with alterations monitored for a 6 month period and revisions endorsed by an expert panel. Monitoring would include subjective and objective performance measures across a stipulated time period for a designated number of pilots.

Recommendation 3: Development of a system enabling companies to allocate work to pilots in a way that is consistent with guidelines for rest breaks

While many variables influence the work schedules of GBR pilots, it is important that a systematic approach for allocating work to pilots that minimises fatigue, maximises safety and complies with rest guidelines is adopted. It should be objective in nature and aim to make the distribution of work and rest more even. Such a system should minimise the occurrence of those instances where pilots perform considerably greater workloads and experience shorter rests as compared with average company figures.

In addressing this issue the following approaches should be considered:

- A review and report by each pilotage company on the criteria currently used to allocate work to pilots. By reviewing this criteria, company personnel may identify objective measures which could be used to allocate work and assess fatigue.
- Explore procedures used to allocate work in other industries e.g. airline.

Review a number of existing practices with the aim of making optimal use of a limited workforce and minimising fatigue in non-alterable situations (e.g. at sea). These include:

- The practice of pilots being on ships for significant amounts of time while not performing any pilotage, particularly on the non-compulsory region of the Inner Route. Given that accommodation facilities on board vessels are frequently less than optimal, this practice may compromise the pilot's level of alertness prior to commencing bridgework. Additionally, during busy periods this practice would not appear to be the most efficient use of a limited workforce.
- The feasibility of having access to a reserve group of pilots who would be available to perform work during busy periods. This group could involve pilots who are semi-retired or who desire a reduced workload. Naturally this group of pilots would be required to comply with all licensing and training requirements.
- Enhance strategies currently used to optimise the utilisation of a small workforce during predictably busy periods. For example, communication with pilotage company officials has confirmed that the increased work availability evidenced in the second time period of the work schedule files (July 1, 1996-December 31, 1996), is an annual occurrence resulting from sugar cane harvesting.
- Pursue the optimisation of the limited sleep opportunities at sea. Strategies such as the charting of the Fairway Channel and extension of navigation facilities in other regions should be undertaken as soon as possible.

More longer term approaches to work allocation would involve developing a computerised system for allocating work in compliance with rest break guidelines.

Recommendation 4: Upgrading reporting procedures of work schedules to: (i) enhance work schedule files with additional information; (ii) monitoring of fatigue potential in a more timely fashion.

(i) Enhancing the present work schedule files with additional information

The present work schedule files are designed to enable pilotage companies and Government authorities to monitor the ship and non-ship time of GBR pilots. As shown in the retrospective analysis of the existing work schedule files a considerable amount of information is available which could be better utilised to monitor pilot fatigue at a basic level. At present not all data within the files is being fully utilised for this purpose. The more appropriate fatigue indicators from these files include:

The number and duration of assignments during a tour; (ii) amount of night work; (iii) the number of assignments undertaken on potentially more stressful shipping routes (i.e. Inner Route); and (iv) the timing of rest breaks. It is also possible from the existing files to identify those situations when considerably greater workloads are undertaken with respect to the number and duration of tours and work assignments, the proportion of night work, and the length of rest breaks. This information is limited however, and the findings from the log book analyses have identified additional items which, if added to the current reporting procedures, would enhance the fatigue monitoring process.

These additional factors were determined from the statistical modelling procedures which were undertaken to identify those work and sleep related factors which were associated with high levels of fatigue and stress and low levels of alertness during bridgework. Further refinement of the present model should be undertaken to include more detailed temporal aspects of work and breaks. However, at this time it is recommended that the following additional items be included to enhance the existing system in relation to fatigue monitoring:

1. total duration of bridge periods;
2. total duration of bridge periods during an assignment and during critical hours; and
3. travel to and from the ship. A draft data collection form based on the results of the preliminary modelling is shown in Appendix 5.

This model should be evaluated and further refined following:

- A 6-month trial period using the enhanced reporting system with all pilots. The information would be analysed monthly and an assessment of the value of the enhanced system made at the end of the 6-month period.
- Extension of the current models to include more detailed temporal aspects of work and sleep patterns. These steps would enable changes in fatigue, stress and alertness during bridgework to be predicted for each additional hour of duty on the bridge, and enable a predictive formula for fatigue, stress and alertness to be calculated.
- More long term strategies may pursue the development of a predictive model for the classification of work difficulty or 'probable fatigue status of pilots' (as described earlier). The classification system could also incorporate an index of difficulty associated with shipping characteristics such as ship type (length and draft), status and flag (States/British Columbia Oil Spill Task Force, 1997).

(ii) Monitoring of rest breaks and fatigue potential in a more timely fashion

A. regulatory/company level;
B. personal level.

(a) regulatory and company level

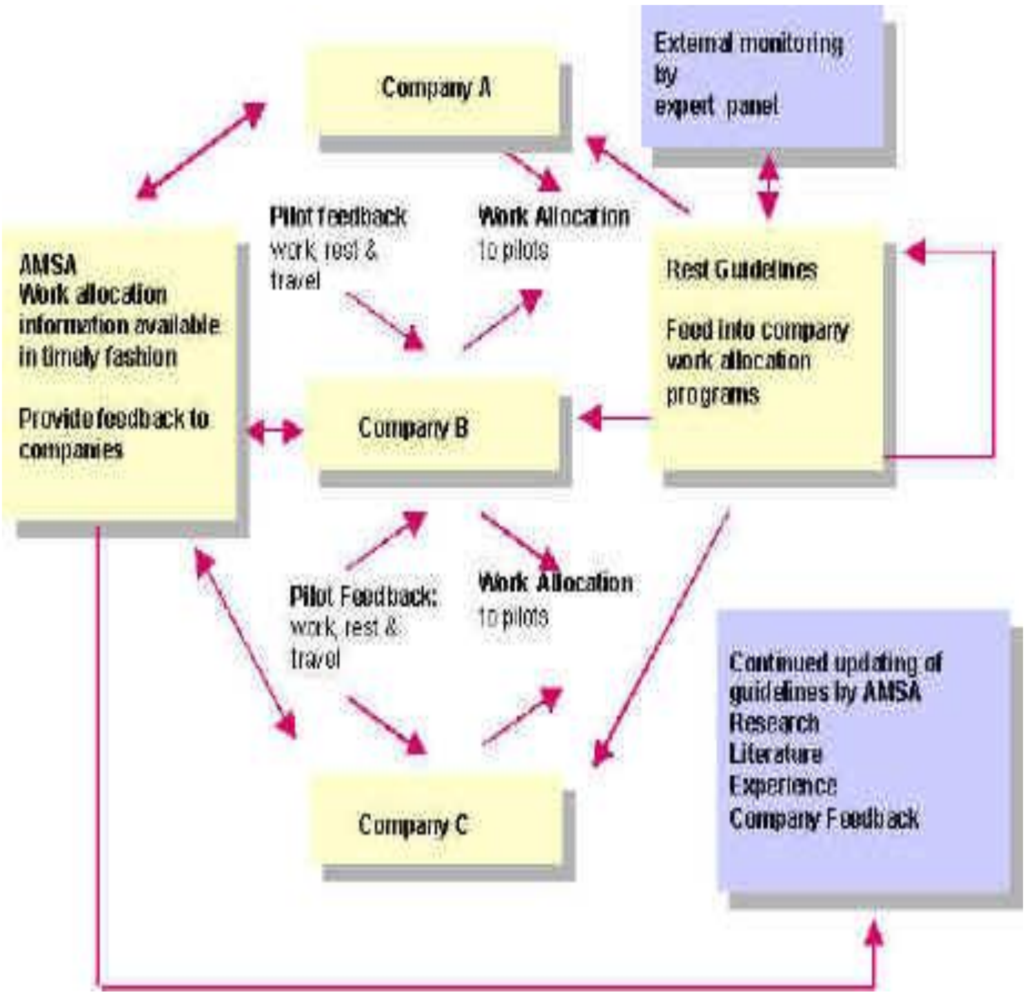
To enable a preventative, rather than a reactive system of monitoring to be implemented, data within work schedule files should be accessed by company personnel and regulatory authorities in real time. This would then enable meaningful intervention to take place, if necessary.

In addressing this issue the following approaches should be considered:

- At a regulatory level, AMSA would be required to maintain an active role in updating the rest guidelines to ensure the regulations are in line with current findings in the areas of work, rest and recovery. This process of updating guidelines should be based on:
- findings from their own research and industry specific experience;

- published findings in the literature;
- feedback from pilot companies; and
- data gathered by the Marine Incident Investigation Unit.
- Pilotage companies should update work schedule files as soon as practical after receiving pilot invoices.
- Explore the practicality of using other on-line maritime reporting systems such as AUSREP to enable AMSA to view and monitor work schedule files in a more timely fashion should be considered.
- In situations where inadequate breaks are unavoidable, explanation of the circumstances should be shown in the file in real time.
- More long term approaches should involve developing a computer program which would alert pilotage company and AMSA personnel when a pilot may have an unacceptable risk of fatigue. This program should be based on objective measures for assessing workload and probable fatigue status of the pilot. Meaningful intervention could then take place and subsequent work could be allocated in such a way to balance the level of work undertaken. A schemata of a possible reporting and monitoring procedure is shown in Figure 1.0.

Figure 1.0 An overview of a suggested reporting and monitoring procedure.



(b) personal level of fatigue monitoring

- Encourage pilots to become pro-active in the fatigue issue by monitoring their own personal fatigue from a short checklist.
- A draft checklist has been designed and is shown in Appendix 4. This may be modified if required and include in the Passage Planning document completed by pilots.

Recommendation 5: Implement an education program on the nature and consequences of fatigue.

Evidence from the many phases of the project indicated the approach to fatigue by the pilotage workforce and participating groups appeared to be based on maritime traditions relating to hours of work and compromised sleep at sea, followed by lengthy recuperative periods ashore. However, pilotage work is considerably different in may aspects to general maritime work; thus attitudes towards fatigue based on the general maritime setting may be quite inappropriate for pilots. Moreover, there appears to be a general acceptance and expectation that demanding work schedules and conditions are a necessary and an unavoidable consequence of being a GBR pilot.

The educational program would be an important component of the overall fatigue management program for pilots and would include information which addresses issues which impact on fatigue such as: the impact of work and sleep in opposition to normal circadian cycles; the effects of fragmented sleep and an understanding of human circadian rhythms; sleep disorders and the lifestyle and other health related issues (Sanquist et al., 1996). In fact, extensive fatigue education programs targeting drivers and managers are currently applied in road and rail sectors of the transportation industry in the US, New Zealand and Australia (Rogers, 1998; Gander et al., 1998; McDonnell & Featherstone, 1998).

In addressing this issue the following strategies should be considered:

- The development of a fatigue education program targeting pilots, company personnel and AMSA officials involved in pilotage matters. This program would supplement personal monitoring of fatigue shown in Recommendation 4.
- An examination of the appropriateness of fatigue training programs such as the National Aeronautics and Safety Administration (NASA) Fatigue Countermeasures Program which offers education in the basic aspects of human performance and fatigue. Other programs such as The Alert Driver (Rogers, 1998) could be used as a general introduction to enhancing fatigue knowledge in marine pilots.
- Providing pilotage specific material to supplement a general fatigue awareness program.
- The incorporation a fatigue education/training program within the existing area of Pilot Professional Development.
- The use of knowledge gained from marine accident investigations internationally and nationally to enhance the content of fatigue education programs for pilots (McCallum et al., 1996; Marine Incident Investigation Unit, Australia).
- Consideration of a distance education approach to fatigue education given the scattered home bases of pilots and the home and away nature of the work.

- The development of a system to regularly and systematically distribute fatigue updates to pilots based on the latest findings from scientific and industry literature. This process would ensure that the fatigue focus is maintained.

Recommendation 6: Review the current medical screening procedures for pilots.

Several factors associated with pilotage work have the potential to impact negatively on long term health outcomes. These include irregular working patterns, displaced work and sleep from normal circadian cycles, night work, and varying levels of physical and mental stimulation (Costa, 1996; Monk & Folkard, 1992; Scott & Ladou, 1990). Similarly, health impairments and decreased fitness levels may have a detrimental impact on work performance, particularly when work involves irregular working hours (Harma, 1993).

During the present and earlier projects substantial evidence has been collected which raises questions regarding the health status of pilots and the adequacy of current medical screening standards for pilots.

Although based on self report data, the present pilots displayed a greater incidence of elevated cholesterol and blood pressure by comparison with other seafarers and population data (Parker et al., 1997); and a considerable number of pilots reported experiencing breathing difficulties while sleeping (Parker et al., Report No 4, 1998). Similarly, several early and more recent studies have also raised concern over the high risk of cardiovascular risk factors such as hypocholesterolemia, hypertension, obesity and low levels of physical fitness in pilotage groups (Shipley, 1978; Saarini, 1992; Harrington, 1972; Berger, 1984; Parker et al., 1997). Despite these health profiles, pilot injury and sickness rates are approximately half those of the working population (Shipley, 1978; Berger, 1984). This finding suggests pilots may tend to ignore early warning signs of health problems, particularly in self-employed situations.

Currently, the level of assessment and frequency (2 yearly) of medical screening for Australian seafarers is also applied to GBR pilots (AMSA, 1995). By comparison most marine piloting organisations in the United States require that pilots health be reassessed yearly after age 55 (States/BC OSTF, 1997). Although not directly comparable, but nevertheless relevant, the extent and frequency of airline pilots medicals tend to be based on: age, the presence of risk factors and the licence type held. It is noteworthy, that some road transport companies require drivers to undertake yearly medicals which also incorporate assessment of fatigue related issues. For instance, these medicals involve preliminary screening for excessive daytime sleepiness as well as risk assessment for sleep disorders such as sleep apnoea (Gander et al., 1998). Given that pilots experience short and fragmented sleep at sea and a considerable number of pilots self-reported breathing difficulties while sleeping, risk assessment for sleep disorders is also warranted for the present pilots.

Thus several factors including the health and age profiles, self employed status of pilots, contemporary knowledge on the consequences of fatigue, and recent approaches to medical screening for those at risk for fatigue related problems indicate the reassessment of current medical standards is appropriate and essential.

In addressing this issue the following strategies might include:

- A review of the current procedures for medical screening of pilots in terms of the type and frequency of assessment.
- A review of medical assessments for other groups (e.g. airline and marine pilots) and adoption and/or modification of assessment standards to suit GBR pilots.
- The development of the most appropriate medical screening procedures which should be undertaken in consultation with an occupational physician/s and with consideration of the age profile of pilots and the fatigue consequences of work and sleep patterns revealed from the current study.
- The promotion of a more preventative approach to health through pilot professional development and ongoing education within that structure. Encourage pilots to consider approaches to health with a view to extending, rather than shortening, their working life.

Recommendation 7: Implement a healthy lifestyle education program to complement Recommendations 5 and 6.

Positive long term health outcomes are closely linked to suitable patterns of health and lifestyle behaviours including appropriate amounts of exercise, sleep, relaxation and the avoidance of risk factors such as smoking and excessive alcohol consumption. The home and away nature of pilotage work, including living in alternate accommodation and reliance on shipboard and hotel meals, places considerable additional demands on maintaining healthy lifestyle habits.

Within the present and previous projects there was considerable evidence that pilots' lifestyle habits were compromised. Both pilots and their wives/partners (Parker et al., 1997, Parker et al., Report No's 4 and 3, 1998) identified a relatively high level and frequency of stress associated with pilotage and raised concerns regarding the impact of this stress on pilot health.

Additionally, in the current investigation a considerable number of pilots were classified as either overweight or obese, 30 percent have been identified as smokers (Parker et al., Report No 4. 1998) and 70 percent of pilots did not comply with National Heart Foundation exercise guidelines to promote cardiorespiratory fitness (Parker et al., 1997).

Health and lifestyle education programs have assumed an important role in fatigue management plans in various transportation sectors (Rogers, 1998; Gander et al., 1998; McDonnell & Featherstone, 1998). The focus of these programs has been on various health and lifestyle topics which are likely to impact on work performance and stress levels.

In addressing this issue, the following approaches might include:

- The implementation of health and lifestyle education programs which include stress coping strategies, exercise and nutritional issues especially for those in home and away work situations.
- Liaision with the School of Human Movement Studies at the Queensland University of Technology regarding the suitability of existing programs for application, with modification, to the pilotage workforce.

- The incorporation of health and lifestyle education into the pilot professional development structure and encouragement of pilots to become proactive on this issue.
- An investigation of the availability of such programs for delivery and monitoring using a distance education approach.
- Trialing and evaluation of health and lifestyle programs with GBR pilots.

Recommendation 8: Enhance the accident/incident reporting procedures with respect to fatigue

It is now acknowledged from recent research work that fatigue may play a considerably greater role in marine accidents than previously identified. The contribution of fatigue to vessel and personnel accidents in the US coastguard has been estimated at 16 and 33 percent, respectively (McCallum et al., 1996). Australian data suggests that fatigue contributes to 10 percent of marine accidents, however, one author has suggested that a figure closer to 30 percent would be more realistic when performance impairments due to chronic fatigue are considered (Filor, 1998).

Knowledge of the precise role of fatigue in transportation accidents has been constrained by several factors. These chiefly relate to the difficulty in detecting human fatigue, and the lack of universal definitions of fatigue and non-standardised accident investigating procedures (Brown, 1994; McCallum et al., 1996; Transportation Safety Board, 1997).

However, progress has been made towards the classification of specific characteristics of work and sleep as predictors of fatigue and increased accident risk (McCallum et al.,1996). For instance, modelling based on the outcomes of casualty investigations found sleep and work duration in the past 72 hours and reports of fatigue symptoms correctly classified 80 percent of casualty cases in terms of the presence of fatigue (McCallum et al., 1996).

Additionally, fatigue has been identified as a contributing factor in a number of groundings involving pilots working within the Great Barrier Reef. In the opinion of Filor (1998) investigations of marine casualties have considerable difficulty in objectively proving the presence of fatigue, particularly chronic fatigue. However, Filor (1998) acknowledged that considerably more effort was required in gathering pre-accident data in relation to work and sleep patterns. It is likely that several key measures associated with fatigue identified in the current work schedule analysis may also be utilised in the identification of both acute and chronic fatigue in pre-accident data collection processes during accident investigations.

A measure of the effectiveness of changes in fatigue management procedures is a reduction in the number of vessel and personnel casualties in which fatigue is likely to have a contribution. It is important therefore that AMSA in conjunction with the marine Incident Investigation Unit implement strategies to more effectively link human factors fatigue information with objective incident statistics.

In addressing this issue the following approaches should be considered:

- Provide information from this research to upgrade the human factors investigation and reporting procedures.

- Review the current procedures for accident investigation to assess the adequacy of the collection and access to information concerning human factors issues.
- Consider the use of the present work schedules in an investigation of chronic fatigue problems during accident investigations. From basic calculations on work schedule data pre-accident data could be evaluated on: (i) workloads (number of tours and assignments across the previous two or three months; (ii) the number and duration of assignments during a tour; (iii) amount of night work; (iv) the number of assignments undertaken on potentially more stressful shipping routes (i.e. Inner Route); and (v) the timing of rest breaks.
- Establish or maintain investigation of the contribution of human factors to accidents/incidents as a priority.
- Establish a close working link between the Marine Incident Investigation Unit, AMSA and the pilot companies with a view to a proactive rather than reactive approach to fatigue issues.

Section 1.0 Background

A recent survey of the lifestyle behaviours and industry specific factors associated with the health, stress and fatigue of Australian seafarers identified several areas which may impinge upon the health and potential for fatigue in GBR pilots (Parker et al., 1997). An important finding was the poor quality and short duration of sleep experienced by pilots at sea which has been shown in other populations to be associated with mood and performance decrements and increased fatigue. While fatigue has clearly been identified as a major factor in accident risk in other transport industries it has only recently been shown that fatigue may be a contributing factor to a significantly greater number of marine accidents than previously reported (McCallum et al., 1996). The nature and demands of marine pilotage in the Great Barrier Reef and the environmental sensitivity of this region was the catalyst for the commissioning by AMSA of an investigation into the work practices of GBR pilots and the likely impact of these work practices on the fatigue of pilots. The project was undertaken by a research team coordinated by the School of Human Movement Studies at the Queensland University of Technology and involved the following phases:

- Phase I (Parker et al., Report No 1, 1998)
    - A review of the existing literature of the work practices of marine pilots.
- Phase II (Parker et al., Report No 2, 1998)
    - Analysis of work schedule data across an 18 month period (1 Jan 1996-30 June 1997) to develop a basic description of ship and non-ship time.
- Phase III (Parker et al., Report No 3, 1998)
    - A background survey of wives/partners of GBR pilots to identify the impact of pilotage work on home and family life and address psychosocial issues.
- Phase IV (Parker et al., Report No 4, 1998)
    - A survey of GBR pilots designed to provide a profile of this group and a general description of their sleep patterns, and their perception of the impact of work and industry factors on alertness, stress and fatigue.
- Phase V (Present Report)

The use of on-tour logs to provide specific information about ship time (bridge and sleep periods) and non-ship time ashore (sleep periods). This information will be used to help validate work schedule data and provide information on the relationship between work/rest patterns and alertness.

The information resulting from these investigations is both comprehensive and complementary and will be applied to the development of strategies and guidelines to reduce the potential for fatigue and risk of accident.

A Pilot Advisory Group, group comprising one member from each of the pilotage companies operating in the Great Barrier Reef – Torres Strait region was formed to provide industry specific direction to the research. This group was involved in the design and validation of the survey instruments and assisted in gaining and maintaining the support and cooperation of the pilot companies and their members. Regular meetings were held with the researchers and representatives from AMSA and there were frequent informal communications between members of the Advisory Group and the research team.

This report primarily presents the results from the on-tour log-book analyses, however, reference is also made to information derived from earlier stages of the research program. The various phases of the program are designed to provide a progressive and complementary analysis of the work practices of GBR pilots using a variety of research strategies. The findings have been combined to identify those aspects of pilotage which have the potential for fatigue and to provide a number of recommendations designed to implement appropriate fatigue management procedures.

Section 2.0 Introduction

The Great Barrier Reef region is recognised both nationally and internationally as a unique and environmentally sensitive area. The region is registered on the World Heritage List and in 1990, was identified by the International Maritime Organisation as the world's first, and to date only, 'Particularly Sensitive Sea Area' (Queensland Department of Transport, 1996; AMSA, 1996). Coastal pilotage in the region is centred on the movement of ships along and through the Great Barrier Reef and into the Torres Strait region, with pilotage assignments ranging from 12 to 60 hours. Pilots often experience testing conditions and have to cope with varying ship, equipment and crew standards (90 percent of the piloted vessels are foreign flag), combined with the vagaries of weather and recreational traffic. Additionally, ships may be carrying potentially hazardous and highly polluting cargo, and are often deep laden causing intricate navigational problems. Extrinsic factors such as the commercial aspects of pilotage appear to have caused considerable additional stress to the pilotage workforce. Regulatory changes to pilotage in 1993 saw the emergence of three competing pilotage companies in the region replacing the 100 year old one provider situation. Hence, it is possible that the characteristics of the work patterns of GBR pilots and a range of extrinsic factors may have the potential to impact on their potential for fatigue and work performance.

Earlier research indicates that a pilots work is generally characterised by irregular scheduling and compromised sleep. For example, work schedule data from United Kingdom pilots (Shipley & Cook,

1980) and the present pilots revealed that the entire 24 hour period was represented and assignment and break starting times commonly occurred outside of the normal circadian cycle. Night work was common and findings from the present investigation indicated that approximately 50 percent of ship time of GBR pilots is undertaken during the night (where night is defined as between 1818 and 0525 hours) (Parker et al., Report No 2, 1998). Compromised sleep at sea has been consistently identified in studies from pilotage groups in the United Kingdom (Shipley & Cook, 1980), the Netherlands (de Vries-Grier, 1982), the Port Phillip region of Australia (Berger, 1984) and the Great Barrier Reef region (Parker et al., 1997). Thus, it would appear that work and sleep patterns in marine pilotage operations are conducive to workplace fatigue. Maritime research has shown that fragmented sleep periods, sleeping at physiologically inappropriate times of day and insufficient time between work periods to obtain restorative sleep were critical factors contributing to mariner fatigue (Sanquist et al., 1996).

Irregular working hours, particularly when involving the whole 24 hour cycle, require working at times which may oppose the natural diurnal biological rhythms of the human body. In this situation sleep quantity and quality are frequently compromised and fatigue occurs. If the fatigue is excessive over the shorter or longer term, decrements in performance may result particularly in cognitive, vigilance and memory tasks (Akerstedt, 1995; Condon et al., 1988; Krueger, 1989; Monk, 1989; Monk & Folkard, 1992; Rosekind et al., 1996; Scott & Ladou, 1990; Transportation Safety Board (TSB), 1997; Griffiths, 1993; Krueger, 1989). The increased accident risk during the early morning hours, particularly 0300 hours, with an additional but smaller peak in accident risk during the mid afternoon has been attributed to working during the circadian trough in alertness (Summala & Mikkola, 1994; Brown, 1994; Couper, 1996; Folkard, 1997; Sanquist et al., 1996; Mitler et al., 1988; Hopkins 1992;). In terms of pilotage performance, this may result in lack of awareness of position and monitoring of navigational equipment, failure to respond quickly to adverse situations, inaccurate calculations, impaired judgment and over-reliance on radar and automated equipment (Couper, 1996; Dinges, 1992; Sanquist et al., 1996).

While in the past, only a small proportion of marine accidents were thought to be fatigue-related, more recent reports from the US and Japan have suggested otherwise. For instance, studies of accidents in US waters have indicated a 10-fold increase in the fatigue contribution to critical vessel and personnel injury casualties since 1993 (McCallum et al., 1996). Japanese investigators found that 'lack of alertness' and 'dozing during navigation' accounted for a significant proportion of groundings, strandings and collisions occurring between 1985 and 1991 (Japan Maritime Research Institute, 1993). Additionally, official Australian statistics revealed 9.2 percent of shipping casualties occurring in Australian waters between January 1994 and January 1998 were fatigue-related. However, one author has suggested that a figure closer to 30 percent would be more realistic when performance impairments due to chronic fatigue are considered (Filor, 1998).

During the present project the approach to exploring fatigue was based on examination of factors identified as potential contributors to stress and fatigue such as irregular work and sleep patterns, and their association with changes in alertness. As self-report measures of alertness have been shown to have a strong association with performance (Gillberg et al., 1994) changes in alertness over a number of bridge assignments were recorded to evaluate the likely impact of work practices on fatigue and work performance. While previous research and retrospective analysis of work schedule data (Parker et al., Report No 2, 1998) has identified factors which potentiate fatigue, more detailed analyses were required to determine the specific details of work and rest at sea and their association with alertness and fatigue. This data will serve to validate earlier data and provide a more complete picture of the work practices of these pilots working under unique conditions and in a very significant region.

Specifically, the final phase of the project was designed to examine:

- details of activity on the ship, including duration and timing of bridge periods;
- the timing and extent of assignment breaks;
- sleep quality, duration and timing at sea and ashore;
- fluctuations of alertness and symptoms of fatigue during bridgework.

Section 3.0 Methodology

Development and implementation of the methodology for this phase of the research program involved primarily the selection of an appropriate instrument to allow pilots to record specific details of work assignments and breaks between these assignments. In this selection process it was necessary to select a valid instrument that could be administered by pilots with minimum disruption to their work. For this purpose a log book used in an earlier study of the work practices of watchkeepers in the US Coast Guard (Sanquist, 1996) and the UK (Seafarers International Research Centre, 1996) was used. The pilot advisory group provided suggestions which were helpful in making modifications to the logbook to improve its relevance to the work of GBR pilots.

3.1 Sample

Logbooks were distributed to 58 GBR pilots. The sample represented the three pilotage companies operating in the Great Barrier Reef region. The two larger companies each employ 29 and 26 pilots, respectively, with 4 pilots employed by the smaller company.

3.2 Log Books

Pocket sized on tour logbooks were designed to: (i) provide specific information on bridgework such as the duration, timing, alertness ratings and fatigue symptoms; (ii) assess the duration, timing and quality of sleep periods at sea and ashore between assignments; (iii) validate the responses from the questionnaires (Parker et al., Report No 4, 1998) and the analysis of ship and non-ship time from the work schedules (Parker et al., Report No 2, 1998); and (iv) identify factors associated with high fatigue and stress and low alertness on the bridge. Pilots were requested to complete the logbooks after each work and sleep period for consecutive work assignments during a tour of duty.

3.3 Log Book distribution and reminder system

Eight logbooks (including a stamped addressed envelope for returns) were distributed by the pilot companies and posted to the home address of each pilot. An information package with the logbooks provided detailed instructions on completing the logs and addressed issues relating to confidentiality and the anonymity of data presentation. A reminder system encouraging project participation consisted of two individual reminders to pilots and facsimile messages to pilot accommodation on Thursday Island.

3.4 Logbook Development

As indicated earlier, a previously validated logbook was modified for implementation in this investigation (Sanquist et al., 1996; Seafarers International Research Centre, 1996) and reviewed by the Pilot Advisory Group to ensure measures specific to Reef pilotage were included. In addition to the pilot advisory group the contents and organisation of the logbook were reviewed by Professor Simon Folkard (Body Rhythms and Shiftwork Centre, University of Wales, Swansea) to ensure the inclusion of key items related to sleep and circadian issues. The main changes to the logbooks included: (i) an assessment of the duration of pilotage time during an assignment; (ii) travel time to and from the ship; (iii) ratings of stress and fatigue levels for an assignment; and (iv) ratings of the degree to which a large number of industry and pilotage specific factors contributed to assignment stress and/or fatigue.

3.5 Pilot Testing of Log Books

The logbooks were tested by a pilot during a work assignment and comments regarding content, suitability and acceptability were provided. These comments were incorporated into the logbooks prior to distribution following consultation with the Pilot Advisory Group. As the original logbooks had been previously used in maritime settings further trialing was not considered necessary. A copy of the logbook content is shown in Appendix 3.

3.6 Measures

3.6.1 Work assignment characteristics

Items in this section were designed to provide a general overview of the assignment and were completed once only. Questions related to: (i) the shipping route; (ii) date, time and location of embarkation and disembarkation; (iii) date and time pilot duties commenced; (iv) date and time pilot duties ceased; (v) travel time to and from boarding grounds.

3.6.2 Work periods on bridge

For each work period on the bridge items in this section were completed. These related to: (I) sea conditions; (ii) date and time of each bridge period; (iii) alertness ratings at the beginning middle and end of a bridge period; and (iii) symptoms of fatigue experienced during bridgework.

Respondents were asked to rate their alertness at the beginning, middle and end of bridge periods on a Visual Analogue Scale (VAS), (range 'very sleepy' to 'very alert'). Alertness values were scored on a 1-9 scale based on the position indicated on the scale.

The dimensions of fatigue symptoms consisted of: (i) forgetfulness; (ii) distractedness; (iii) attention difficulties; (iv) decreased motivation; (v) did things at wrong time; (vi) sore muscles; (vii) heavy eyelids; (viii) desire to sit or lay down; (ix) itchy eyes; and (x) difficulty focusing eyes. Respondents were asked to rate the frequency of experiencing fatigue symptoms. Items were scored on a five-point Likert scale ranging from 'not at all' (Scale =1) to 'very much' (Scale = 7) with a single total score calculated (range 10-70). A higher score was associated with a greater frequency of symptoms.

3.6.3 Sleep periods at sea

Items in this section were completed for each sleep period at sea. Items related to: (i) sea conditions; (ii) date and time of sleep periods; (iii) duration of sleep periods; (iv) time to fall asleep; (v) number of awakenings; and (vi) ratings of sleep quality. Sleep quality was assessed on the dimensions of ease of falling asleep, ease of rising, sleep period sufficiency, restedness and sleep depth. Respondents were asked to rate sleep quality on a five-point Likert scale ranging from 'least' (Scale =1) to 'most' (Scale = 5), with a single total score calculated (range 5-25). A higher score indicated greater sleep quality.

3.6.4 End of work assignment assessment

This section was completed once only, at the end of a work assignment at sea. Items in this section were designed to examine the overall stress and fatigue of the work assignment. Respondents were asked to rate their stress and fatigue levels for the assignment on a Visual Analogue Scale (VAS), (range 'very sleepy' to 'very alert'). Stress and fatigue was scored on a 1-100 scale based on the position indicated on the scale.

Additionally, this section assessed the degree to which industry specific factors increased overall stress and/or fatigue. Dimensions of industry specific factors related to: (i) bridge team; (ii) ship length; (iii) ship speed; (iv) cargo type; (v) equipment availability; (vi) ship handling capabilities; (vii) under keel clearance; (viii) weather; (ix) visibility; (x) shipping traffic; (xi) recreation traffic; (xii) language communication difficulties; (xiii) meals; (xiv) accommodation; (xv) travel to the boarding ground; and (xvi) travel from the boarding ground. Respondents were asked to rate the degree of contribution of these factors on a Visual Analogue Scale (range 'not at all' to 'very much'). On the basis of factor analysis three subscales were identified. These were: ship and environment factors, onboard factors and travel factors.

3.6.5 Additional comments

A separate page was provided to record any additional comments relating to issues not addressed in the logbook and to expand on problems encountered during particular assignments.

3.6.6 Sleep periods ashore

This section was completed each time pilots slept ashore between work assignments and was recorded for up to three days. The issues covered were identical to those addressed in the sleep periods at sea.

3.7 Data Analysis

3.7.1 Quantitative Data

The quantitative data was analysed using SAS-PC and standard univariate statistics were used to describe responses. Repeated measures Analysis of Variance (ANOVA) was undertaken to compare mean aggregate scores for logbook variables on the Inner Route, Hydrographers Passage and the GNE Channel. When there was significant evidence of differences, post-hoc tests were used to clarify the nature of those differences.

Some modification of existing scales was undertaken to improve reliability and validity of responses. However, in all cases, the aggregate scores were re-scaled so that they had the same maximum and minimum as the original scales enabling comparisons with data from other occupational groups to be made (Barton et al., 1995; Sanquist et al., 1996).

Factor analysis, using the principal components method to extract the initial factors and a promax (oblique) rotation method, was used to help identify constructs underlying a series of questions dealing with factors contributing to work assignment stress and fatigue. Further item analysis involving assessment of the reliability of scales and their interpretability, was undertaken before the scales were finalised. Items included in the sub scales are shown in Section 3.6.4.

Cronbach's alpha coefficients were calculated to determine the reliability of each of the aggregate scores used in the report. Scales showed a high level of reliability with Cronbach's alpha coefficients for travel factors, onboard factors and ship and environment factors being 0.73, 0.87 and 0.90, respectively.

A cut-off of 0.01 was used to assess the statistical significance of p-values in order to exercise some control over the overall experimentwise error rate (type I error rate) and minimise the number of spuriously significant results.

A series of multiple linear regression models were used to assess contributions to variation in mean overall fatigue, stress, and minimum alertness measures of pilot data reflecting ashore and at-sea variables. After accounting for the variation in fatigue, stress, and alertness among the pilots, six incremental levels of modelling were attempted, each level evaluated a set of data at a higher level of data refinement, considering the percentage of additional variation in fatigue, stress, and alertness accounted for by:

1. the duration of the break preceding an assignment;
2. travel duration to and from the ship per assignment;
3. work variables, including the duration of the work assignment, duration of pilotage duties, duration of time on the bridge, average duration of bridge periods per assignment, number of bridge periods per 24 hour period during the assignment; and number of critical hours spent on the bridge
4. total duration of time in bed per 24 hours at sea;
5. total duration of sleep during the break preceding the assignment; and
6. total duration of non critical sleep during a break.

These models were considered for the Inner Route only, as there were insufficient work and sleep periods for meaningful analysis of the other two routes. R2 values and changes in R2 values across the incremental models, expressed as percentages of variation in fatigue, stress, and alertness accounted for by the variables in the model, were used to summarise the results.

3.7.2 Qualitative Data

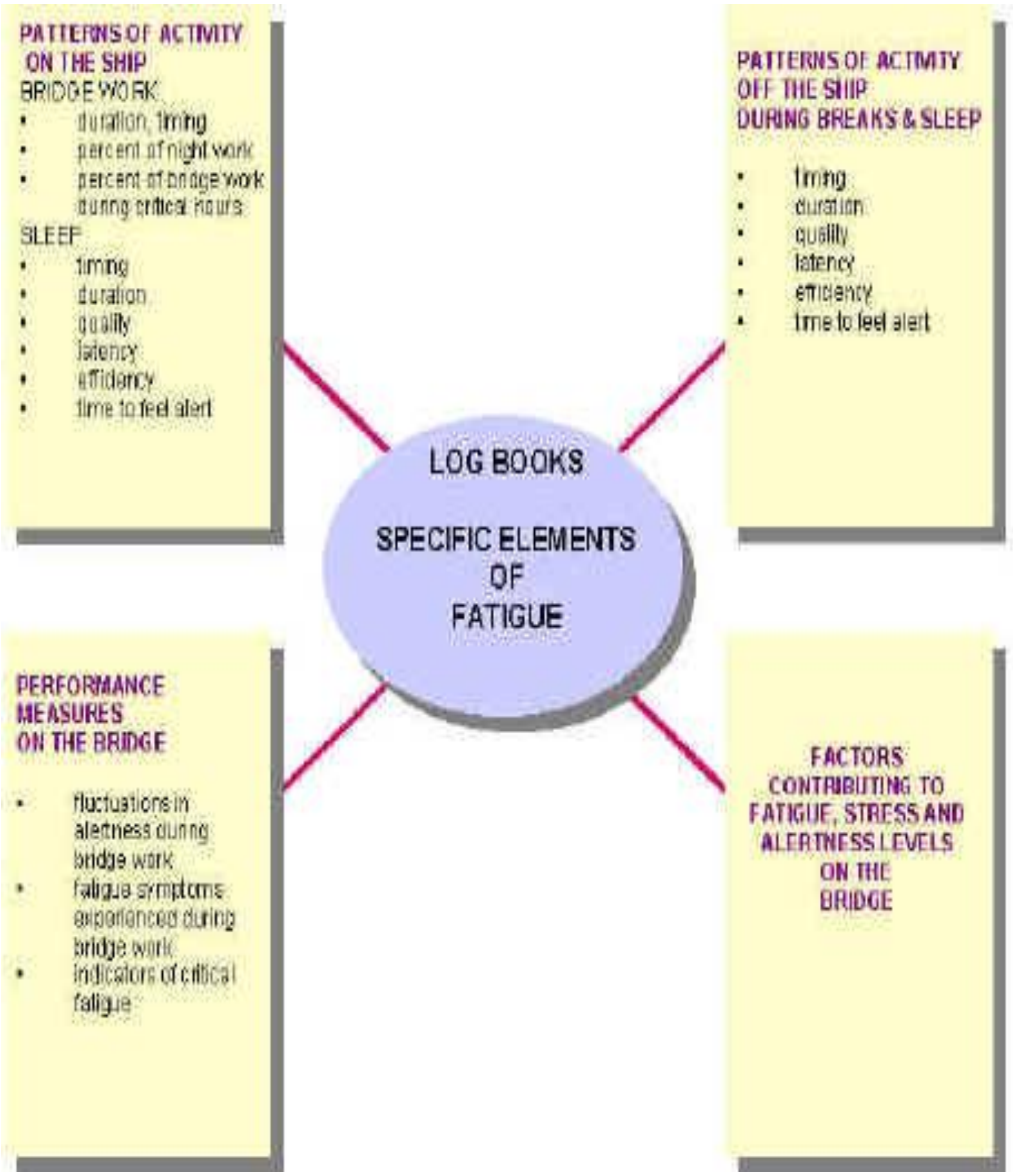
Participants were requested to include any additional comments on the issues covered within the logbooks or on topics that were omitted from the logbooks. These comments facilitated the interpretation of the logbook data given the large variation in work assignments, and provided a clearer understanding of the context within which responses to the logbooks were made.

This qualitative data was analysed by examining the comments for recurrent patterns and themes. The data has been incorporated within the relevant sections of the results.

3.8 Presentation of Results

Results of the logbook analysis in the present report are presented in four key sections: (i) patterns of activity on the ship (bridgework and sleep); (ii) patterns of activity during breaks (sleep); (iii) measures of alertness and fatigue on the bridge; (iv) factors contributing to fatigue, stress and alertness on the bridge. Figure 3.0 shows a schematic view of the presentation of results.

Figure 3.0 Schematic diagram of key measures from the logbooks



4.0 General Characteristics

4.1 The Sample

The average age of the pilots was 53.2 (+ 1.64) years. Examination of the age categories indicated 70 percent were aged between 41 and 60 years, three pilots were in the 31-40 age category, and seven were aged between 61 and 70 years. On average, pilots had served 36 years in the general maritime industry with 9.5 years of service in Great Barrier Reef pilotage. Years of service as a Great Barrier Reef pilot ranged from 11 months to 27 years, with 50 percent serving more than 7 years and a similar percentage serving for less than that time (Parker et al., Report No 4, 1998).

4.2 Response Details

Twenty-three pilots or 40 percent of the total pilot group provided logbook data on 176 work assignments undertaken on the three main shipping routes in the Great Barrier Reef-Torres Strait region during May-June, 1998. By comparison, 60 percent of the same pilots responded to questionnaires during an earlier phase of the project (Parker et al., Report No. 4, 1998). The response rate for the logbook analysis was lowerthan anticipated and may reflect the reticence of some pilots to maintain and complete the logbooks over this period, which is not unusual in occupational settings.

Analysis of the logbooks was based on the number of assignments, and bridge and sleep periods (Table 4.0). The number of assignments and bridge periods was adjusted for any missing values and sleep data ashore was based on 165 assignments after counting only those breaks of 3 days or less. The number of sleep periods at sea was based on 146 assignments.

Table 4.0 Logbook measures: Number of work assignments, bridge and sleep periods, by shipping route.

Key Measures	Inner Route	Hydrographers Passage	GNE Channel	Other	All
No. of work assignments	120	34	18	3	176
No. of bridge periods	997	39	24	12	1074
No. of sleep periods at sea	796	22	6	9	833
No. of sleep periods ashore	336	62	43	11	452

4.3 Limitations

Logbook data should be interpreted with caution for the following reasons:

- The relatively small group of respondents may not be representative of the total pilot population;
- The lack of precision of data recorded on the GNE Channel due to the relatively small number of work assignments in this region during the period of data collection; and
- The possibility that respondents overestimated their level of alertness and quality of sleep;

While these limitations to the interpretability of the logbook data may lead to an over- or underestimate of the associations between work and sleep and fatigue, stress, and alertness, they are unlikely to distort the overall study findings to any degree.

5.0 Overview of Work Assignments

The following section shows the general characteristics of work assignments for each of the shipping routes. The results focus on the characteristics of work assignments which have the potential to increase fatigue levels such as travel to and from ships, the duration of assignments and pilotage duties, and starting times of work assignments and breaks. Findings relating to the level of overall stress and fatigue, and factors contributing to this during work assignments are also presented.

Work assignment time includes travel to and from the ship and provides a broad description of ship time.

5.1 Travel Duration to and from Ships per Assignment

An assessment of the duration of travel to and from ships per assignment was undertaken to determine the time spent on work-related travel and whether the time spent travelling was different across the shipping routes. Travel times to and from ships for the Inner Route, Hydrographers Passage and the GNE Channel were 2.36 hours, 2.2 hours and 3.69 hours, respectively. Significantly longer time was incurred travelling to and from ships on the GNE Channel, with the duration similar on other routes (Table 5.0). The travel times were consistent with the results from the retrospective analyses of work schedule data (Parker et al., Report No 2, 1998).

5.2 Total Duration of Work Assignments

Previous analysis of the work schedule information had revealed that travel significantly ($p < 0.001$) increased the duration of work assignments so the present assignment duration was adjusted for travel to and from ships. Following this adjustment, findings from the logbook analyses confirmed the earlier data (Parker et al., Report No 2, 1998) and showed that Inner Inner Route assignments were significantly longer (55 hours) than pilotages on Hydrographers Passage (16 hours) and the GNE Channel (14 hours), (Table 5.0).

5.3 Percent or Work Assignments on Pilotage Duties

Further analysis of logbook data provided some insight into the proportion of work assignment time (i.e. time on the ship) spent on pilotage duties. As Figure 5.0 illustrates the percent of the work assignment spent on pilotage duties ranged from 67 percent for Hydrographers Passage to 94 and 95 percent for the Inner Route and the GNE Channel, respectively. Assignments on Hydrographers Passage involved a significantly lower percent of time on pilotage duties compared with the Inner Route or the GNE Channel, which were similar (Table 5.0)

Likewise, in terms of the actual hours spent on pilotage duties during assignments, Inner Route assignments involved significantly more hours (50) than either Hydrographers Passage (8.3) or GNE Channel (9) pilotages (Table 5.0), which were similar.

Figure 5.0 Mean percent of work assignment time spent on pilotage duties, by shipping route.

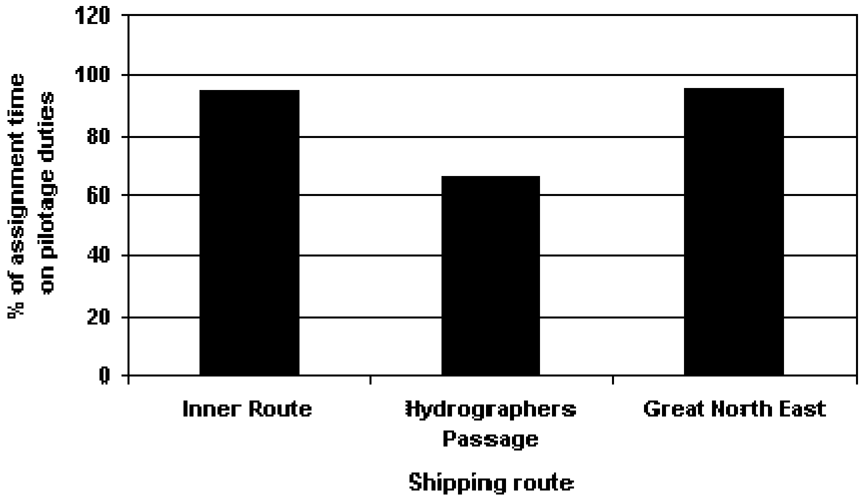


Table 5.0 Analysis of work assignment characteristics, by shipping route (1)

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Travel duration (hours) to and from ships per assignment				
Inner Route	1	2.36 (0.15)	13.15	< 0.001
Hydrographers Passage	1	2.20 (0.19)		
GNE Channel	2	3.69 (0.50)		
Total duration (hours) of work assignments per shipping route				
Inner Route	1	54.59 (2.73)	54.99	< 0.001
Hydrographers Passage	2	16.28 (0.91)		
GNE Channel	2	14.41 (2.14)		
Total duration (hours) of pilotage time per shipping route				
Inner Route	1	49.39 (2.28)	72.27	< 0.001
Hydrographers Passage	2	8.30 (0.25)		
GNE Channel	2	9.05 (0.79)		
Percent of work assignment on pilotage duties				
Inner Route	1	94.87 (0.82)	19.87	< 0.001
Hydrographers Passage	2	66.28 (3.93)		
GNE Channel	1	95.24 (4.52)		
Duration (hours) of breaks between assignments				
Inner Route	n/a	72.52 (11.23)	3.08	=0.051
Hydrographers Passage	n/a	35.99 (13.26)		
GNE Channel	n/a	59.34 (11.53		

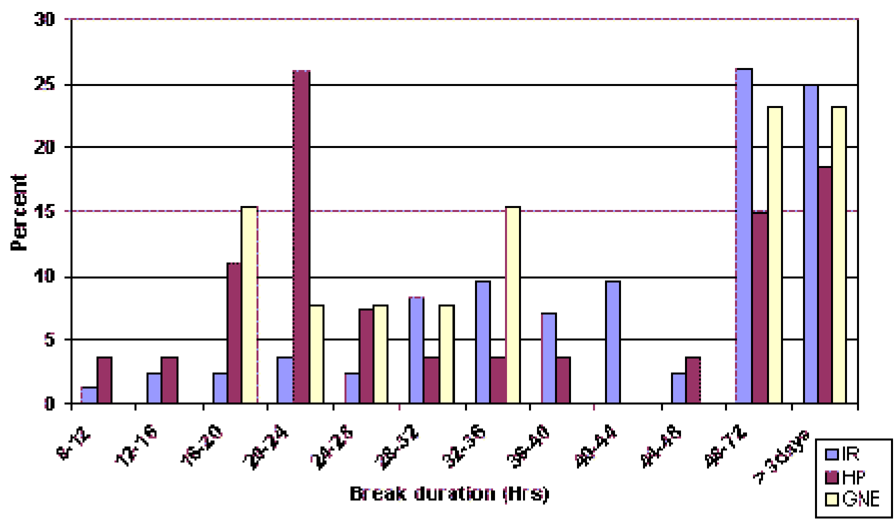
1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range test for post-hoc differences (Type 1 Error Rate = .01) $p < 0.01$ for differences between shipping routes from post-hoc; n/a = Post hoc testing not performed when main effects not significant. $ Includes travel to and from ship

5.4 Duration of Breaks between Assignments

Breaks between assignments present an opportunity for pilots to recover from the previous pilotage and prepare for the next. Hence, an examination of the breaks was relevant to the fatigue focus of the study. Average break duration prior to assignments ranged from 36 hours for Hydrographers Passage to 59 and 72 hours for the GNE Channel and Inner Route, respectively (Table 5.0). The absence of a shipping route effect for assignment break duration possibly reflects the large standard error associated with the mean scores for each of the shipping routes.

The variability in assignment breaks shown in Table 5.0 is explored in the presentation of the duration of breaks as a frequency distribution (Figure 5.1). The figure shows that across all three shipping routes 15-25 percent of breaks before assignments were 48 hours or more, with between 5 and 10 percent of breaks between 24 and 36 hours. A small percentage of breaks prior to work on the Inner Route and Hydrographers Passage did not comply with break duration guidelines for these routes. That some breaks ashore based on both logbook and work schedule results (Parker et al., Report No 2, 1998) were shorter than prescribed guidelines, suggests some personnel had a far shorter time to recuperate between assignments and were at increased risk to develop cumulative fatigue during a tour of duty.

Figure 5.1 Frequency distribution - duration of breaks between assignments, by shipping route.



5.5 Starting Times of Work Assignments of Work Assignments and Break between Assignments

Several studies (Berger, 1984; Shipley, 1978; Shipley & Cook, 1980) support our earlier finding which show the irregularity of the work of GBR pilots. Pilots' hours are dependent on various factors over which they have little control including the weather conditions, tidal patterns and shipping movements in and around the Barrier Reef and Torres Strait Regions. Starting and finishing times may be at any time of the day or night and consequently pilots will often work or sleep at times inconsistent with their normal circadian rhythms. The incompatibility between the person's circadian functions and their work rest schedules causes tensions, fatigue and sleep problems (Barton et al.,1993; Harma,1993). For these reasons it was considered important to examine the irregularity of work and rest periods more closely and the timing of work and rest periods. Frequency distributions of the starting times of work assignments and breaks are shown in Figure 5.2 and Figure 5.3, respectively. As Figure 5.2 indicates between 20 and 25 percent of work assignments began across most 4-hour periods within the 24 hour cycle, with approximately 5 percent of assignments starting between 2100 and 0100 hours on the three routes.

Break starting times depicted a more rectangular distribution across the 24 hour cycle (Figure 5.3); (that is, a similar percent of breaks started during all 4-hour periods of the day). Thus the logbook data again confirmed the irregularity of pilotage work and the disruption to the normal circadian cycles for work and sleep. These findings indicate a considerable percentage of sleep periods during breaks were taken at times inconsistent with maintenance of normal sleep patterns and this issue will be explored in a subsequent section relating to sleep ashore.

Figure 5.2 Frequency distribution - starting times of work assignments, by shipping route.

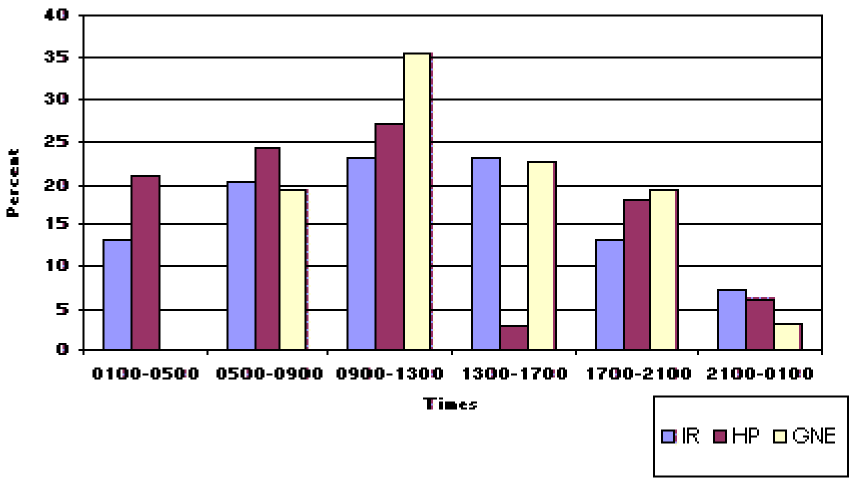
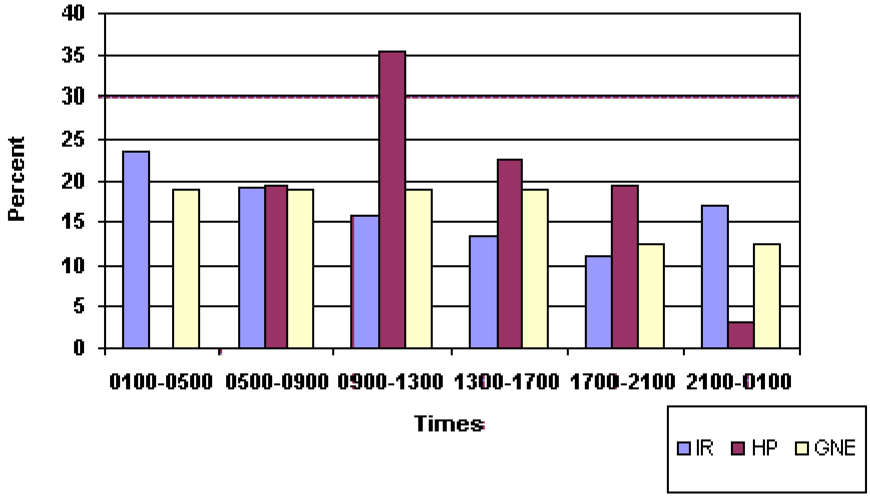


Figure 5.3 Frequency distribution - starting times of breaks between assignments, by shipping route.



5.6 An indication of Work and Rest at Sea and Time onboard and ashore

The percentage of time spent on board spent on pilotage duties working and resting during assignments also has the potential to impact on fatigue and accordingly was calculated from logbook entries. As pilots are on call at all times while on pilotage duties the proportion of a work assignment time spent on pilotage duties was considered as work. As shown in Table 5.0 the percent of work assignments spent on pilotage duties ranged from 66 percent on Hydrographers Passage to 95 percent for the other two routes.

Thus, the ratio of pilotage to non pilotage time while on board revealed some notable differences. For Hydrographers Passage the ratio was 2:1, whereas on the other routes the figure was 19:1 indicating a greater involvement in pilotage duties during higher intensity of work during assignments on these two routes. The pilotage to non pilotage ratio for Hydrographers Passage is also consistent with previous work assignment measures which have shown fewer demands associated with pilotage work in this region.

An earlier finding arising from the earlier analysis of the work assignment and break time showed that 43 percent of tour time was spent onboard with 57 percent spent ashore. This finding was consistent with that arising from the earlier work schedule analysis (Parker et al., Report No 2, 1998) and showed that a slightly higher proportion of tour time was spent ashore than onboard. Thus over a tour, pilots spend approximately equal amounts of time onboard and ashore.

5.7 End of Work Assignment Ratings

The findings in the preceding sections presented statistical evidence of a shipping route effect on several features of work assignments. Results from earlier phases of the present project, particularly the questionnaire responses and pilot commentaries (Parker et al., Report No 4, 1998), also showed that the stress and fatigue experienced by pilots varied greatly between assignments. It was considered important therefore to examine the pilots perception of stress and fatigue for a particular work assignment.

Respondents were required to rate both their overall stress and fatigue on visual analogue scales. Scoring for the scale ranged from a rating of ‘very low’ (scale = 0) to ‘very high’ (scale = 100).

5.7.1 Stress

Work assignment stress was rated as low, and scores ranged between 18 and 27, with no significant shipping route effect (Table 5.1). The absence of a difference between shipping routes is likely related to the large standard errors associated with the mean scores for Hydrographers Passage and the GNE Channel. The considerable variation in stress levels during assignments identified in the comments of individual pilots is reflected in the large standard errors reported here.

5.7.2 Fatigue

Fatigue ratings resulting from work assignments were also fairly low and ranged from 14 on Hydrographers Passage to 29 for the Inner Route and GNE Channel (Table 5.1). Post hoc analysis revealed assignments on the Inner Route and GNE Channel were significantly more fatiguing than those on Hydrographers Passage. The higher rating of fatigue for Inner Route work is not surprising given the considerably longer assignment duration on this route, the fragmented sleep and the navigational difficulties in some sections.

Given that Hydrographers Passage and the GNE Channel are of similar duration (14-16 hours); the higher fatigue rating for Great North East assignments may be related to the navigational demands in the region, the greater amount of travel incurred to/from assignments in this area (Section 5.1) and the greater presence of medium sea conditions during the sampling period between May and June (Section 6.5).

Table 5.1 Analysis of work assignment ratings of stress and fatigue, by shipping route (1)

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Overall Stress				
Inner Route	n/a	22.05 (1.48)	0.02	=0.983
Hydrographers Passage	n/a	18.96 (3.65)		
GNE Channel	n/a	27.37 (5.17)		
Overall Fatigue				
Inner Route	1	28.69 (1.84)	7.98	< 0.001
Hydrographers Passage	2	14.20 (2.17)		
GNE Channel	1	28.98 (5.57)		

1. Results of full two-way Analysis of Variance (ANOVA) model. p < 0.01 considered statistically significant.

2. Results of Tukey's Studentised Range test for post-hoc differences (Type 1 Error Rate = .01) ;$p < 0.01$ for differences between shipping routes from post-hoc; n/a = Post hoc testing not performed when main effects not significant

5.8 Factors contributing to overall stress and/or Fatigue During a Work Assignment

Findings from an earlier survey of the health and stress of Australian seafarers (Parker et al., 1997), which included GBR pilots revealed that a large number of industry specific and personal factors contributed to overall stress and/or fatigue levels during work assignments. In this study these factors were examined in greater depth and respondents were asked to rate on a visual analogue scale, the degree to which a range of pilotage specific factors contributed to overall stress and/or fatigue during a work assignment. Scoring for the scale ranged from a rating of 'not at all' (scale = 0) to 'very much' (scale = 100). Higher scores indicated a greater contribution to assignment stress and/or fatigue.

On the basis of factor analysis three sub-scales were identified. These were: ship and environment; onboard factors; and travel factors.

5.8.1 Ship and Environmental Factors

Ship factors consisted of six items. These were: ship length; ship speed and draft; cargo type; equipment availability; and handling capability. Environmental factors consisted of four items, namely, weather, visibility, shipping and recreational traffic. Cronbrach's reliability coefficient for this scale was 0.90.

The degree of contribution from ship and environment factors was quite low with scores ranging from 10-17. As Table 5.2 shows there was a marginal shipping route effect route effect with ship and environment factors contributing to a greater degree during pilotages on the Inner Route and the GNE Channel than on Hydrographers Passage. Pilot commentaries indicated that in some of the difficult sections of the Inner Route and GNE Channel under keel clearance and handling capabilities of the ship were added problems. Comments also revealed that equipment varied greatly from ship to ship and ranged from 'state of the art' to 'very basic'.

That environmental factors contributed to a greater degree on Inner Route and GNE Channel assignments was not unexpected. These two shipping routes are located in the northern most area of the Barrier Reef pilotage region and are more exposed to changes in weather patterns. The finding that shipping traffic also added more to stress on these routes is expected given the location of the Inner Route in proximity to coastal ports. Individual comments from pilots raised concern over the safety aspects of fishing and sailing vessels being in shipping channels on the Inner Route, especially when these vessels are without proper navigational lights or lookouts.

Table 5.2 Analysis of the degree to which ship and environment factors contributed to assignment stress and/or fatigue, by shipping route (1)

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Ship and environment factors				
Inner Route	1	15.55 (1.14)	3.71	=0.027
Hydrographers Passage	2	9.47 (1.60)		
GNE Channel	1	17.46 (2.65)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range test for post-hoc differences (Type 1 Error Rate = .01) $p < 0.01$ for differences between shipping routes from post-hoc

5.8.2 Onboard factors

Factors related to the onboard scale consisted of four items. These were the bridge team, language difficulties, meals and accommodation. Cronbach's reliability coefficient for this scale was 0.87.

An analysis of the shipping route effect in the degree to which the competency of bridge teams and language difficulties, contributed to overall assignment stress and/or fatigue is shown in Table 5.3. Across the three shipping routes, the contribution from these items was relatively low with scores ranging from 13 to 18). That onboard factors relating to bridge teams, meals and accommodation impacted slightly more on the Inner Route is consistent with the longer assignment duration in this region and the possibility of an exposure to these factors for up to 55 hours or more.

Comments from pilots indicated that well trained bridge teams greatly reduced stress during assignments, whereas poorly trained watch officers reduced the opportunities to sleep for even short periods. Bridge team competency levels were a source of concern to a considerable number of pilots. Pilots reported that in some cases, bridge team members were unable to perform basic lookout duties, helmsman were unable to steer correctly, and pilots repeatedly had to ask for the vessels position to be plotted.

Pilots considered comfortable accommodation was extremely important for relaxation as well as sleep while at sea. Problems with accommodation were identified including the absence of air conditioning, pilot accommodation doubling as an office/computer room, noise from announcements and sharing accommodation with cockroaches.

Table 5.3 Analysis of the degree to which onboard factors contributed to assignment stress and/or fatigue, by shipping route (1)

Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Onboard factors				
Inner Route	n/a	18.33 (1.27)	2.77	=0.067
Hydrographers Passage	n/a	13.00 (1.71)		

GNE Channel	n/a	15.56 (2.16)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant.

n/a = Post hoc testing not performed when main effects not significant

5.8.3 Travel factors

This scale consisted of two items, namely travel to and from the ship. Cronbach's reliability coefficient for this scale was 0.73.

Scores for travel to and from ships ranged from 26 to 34 and were almost double those estimated from other items. Further analysis showed that travel contributed to a similar degree to assignment stress and/or fatigue across the three shipping routes (Table 5.4). Thus, of all the factors assessed, travel was the most significant contributor to overall assignment stress and/or fatigue. Given that travel transfers are often 2-3 hours and 50 percent of this travel is during night time periods the greater impact from travel was not surprising.

That the scores for travel during GNE Channel and Hydrographers Passage transfers were marginally higher may reflect the longer duration of travel times incurred when operating in GNE region and the helicopter transfers on Hydrographers Passage. Some pilots identified situations in which they considered their stress levels were markedly increased such as, repeated attempts by their transfer plane to land during bad weather and during helicopter landings on small ships fitted with cranes. Moreover, 2-3 hour launch transfer times were often doubled due to delays.

Table 5.4 Analysis of the degree to which travel factors contributed to assignment stress and/or fatigue, by shipping route (1)

Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Travel to and from ship				
Inner Route	n/a	26.16 (1.82)	1.14	=0.325
Hydrographers Passage	n/a	31.11 (3.61)		
GNE Channel	n/a	34.92 (5.69)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant.

n/a = Post hoc testing not performed when main effects not significant

5.8.4 Other factors

Logbook commentaries from pilots drew attention to several additional sources of stress associated with work assignments. Pilots considered that while delays were very much part of shipping, in many instances the stress associated with delays was exacerbated when very late notice was given to pilots and launch crews of changed arrival/departure times. Pilots regarded the improper notice of changed arrival and departure times reflected poorly on the level of professionalism associated with the managerial side of the pilotage service.

Commentaries in the logbooks again drew attention to the issue of competition and its negative impact on many aspects of pilotage work, particularly income and safety.

6.0 Bridgework

The previous sections and earlier stages of the project have provided a description of the general characteristics of work assignments. This section focuses on the features of bridgework including the timing and duration, extent of bridgework in critical time periods and differences in these measures across the 3 shipping routes.

6.1 Total Duration, Number and Duration of each Bridge Period per Assignment

An average assignment involved bridgework which totalled 21.8 hours on the Inner Route, 7.45 hours on Hydrographers Passage and 8.9 hours on the GNE Channel (Figure 6.0). The significantly longer total duration of bridge periods on the Inner Route reflects the longer assignment duration of 54 hours for this route.

The extended hours of bridgework on the Inner Route was completed over an average of 7 periods. In contrast, on the shorter routes bridgework averaged 1 period, with this occasionally being more than one. The length of individual bridge periods averaged 3 hours on the Inner Route compared with 6.6 hours on the other routes (Table 6.0). This finding indicates that the shorter routes involved one longer period of bridgework in contrast with multiple bridge periods of shorter duration on the Inner route.

Figure 6.0 Mean total duration and number of bridge periods per assignment, by shipping route

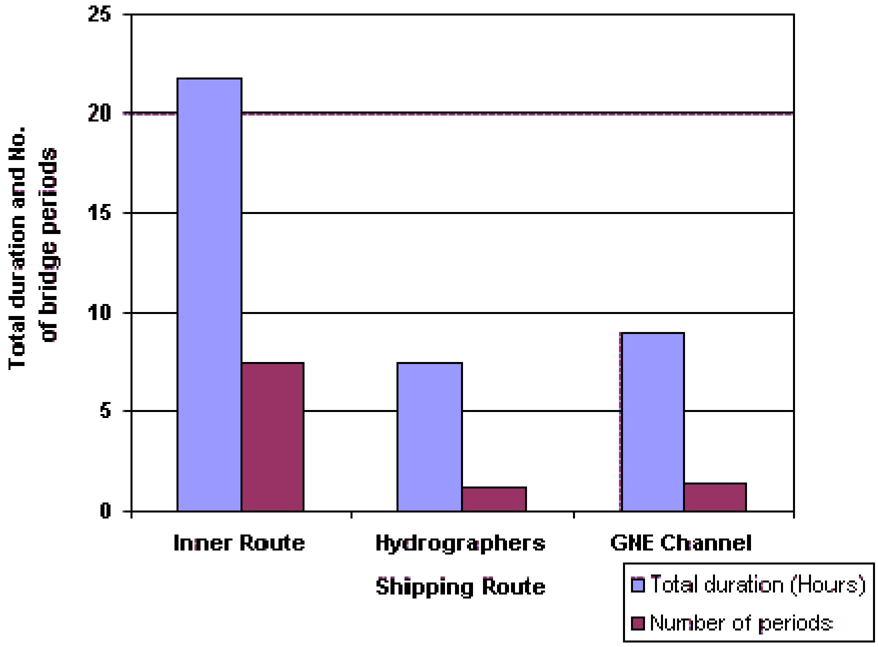


Table 6.0 Analysis of the total duration, number and duration of each bridge periods per assignment, by shipping route (1)

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Total duration (hours) of bridge periods per assignment				
Inner Route	1	21.81 (2.95)	7.36	= 0.001
Hydrographers Passage	2	7.45 (0.82)		
GNE Channel	2	8.90 (0.68)		
Number of bridge periods per assignment				
Inner Route	1	7.51 (0.16)	263.27	< 0.001
Hydrographers Passage	2	1.14 (0.07)		
GNE Channel	2	1.33 (0.11)		
Average duration (hours) of bridge periods				
Inner Route	n/a	2.66 (0.36)	2.14	= 0.184
Hydrographers Passage	n/a	6.63 (0.80)		
GNE Channel	n/a	6.67 (0.58)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range test for post-hoc differences (Type 1 Error Rate = .01 $p < 0.01$ for differences between shipping routes from post-hoc

n/a = Post hoc testing not performed when main effects not significant

6.2 Percent of Pilotage Time spent on the Bridge

A further question to be addressed in terms of potential fatigue was the proportion of pilotage time spent on the bridge itself.

As Figure 6.1 shows the percent of pilotage time on the bridge ranged from 52 percent on the Inner Route to 86 and 98 percent for Hydrographers Passage and GNE Channel assignments, respectively. Statistical analysis revealed that the percentage of pilotage time on the bridge was significantly shorter for the Inner Route, with the percentage similar for the other shorter routes (Table 6.1). Thus on the shorter routes pilots spend nearly all of the pilotage time on the bridge.

Figure 6.1 Mean percent of pilotage time spent on the bridge, by shipping route

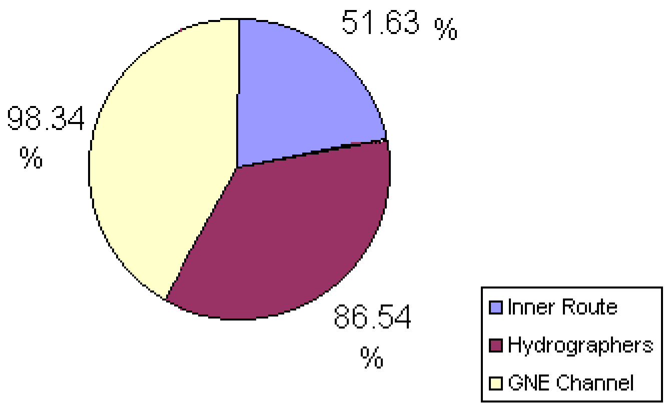


Table 6.1 Analysis of the percent of pilotage time spent on the bridge, by shipping route (1)

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Percent of pilotage time on bridge				
Inner Route	1	51.63 (5.04)	8.57	=0.003
Hydrographers Passage	2	86.54(9.82)		
GNE Channel	2	98.34 (3.49)		

1. Results of full two-way Analysis of Variance (ANOVA) model. p < 0.01 considered statistically significant.
2. Results of Tukey's Studentised Range test for post-hoc differences (Type 1 Error Rate = .01) p < 0.01 for differences between shipping routes from post-hoc

6.3 Percent of Bridgework at night and during critical hours

Earlier findings indicated that approximately 50 percent of ship time occurred during night hours. This figure was not unexpected given that starting times of assignments are distributed across the entire 24 hour period (Parker et al., Report No 2, 1998).

Logbook entries indicated that the percent of bridge time at night ranged from 37 percent for Hydrographers Passage, to 47 and 52 percent for the Inner Route and Hydrographers Passage, respectively (Figure 6.2). The absence of a significant shipping route effect is most likely related to the large standard errors associated with the mean values for Hydrographers Passage and the GNE Channel (Table 6.2).

The percent of bridge time during critical hours ranged from 28 percent for assignments on Hydrographers Passage to 29 percent for those on the Inner Route and GNE Channel (Figure 6.2). Thus, approximately one third of bridge time across all shipping routes occurred during time periods which are associated with decreases in alertness.

Figure 6.2 Mean percent of bridge time at night and during critical hours (2300-0600), by shipping route.

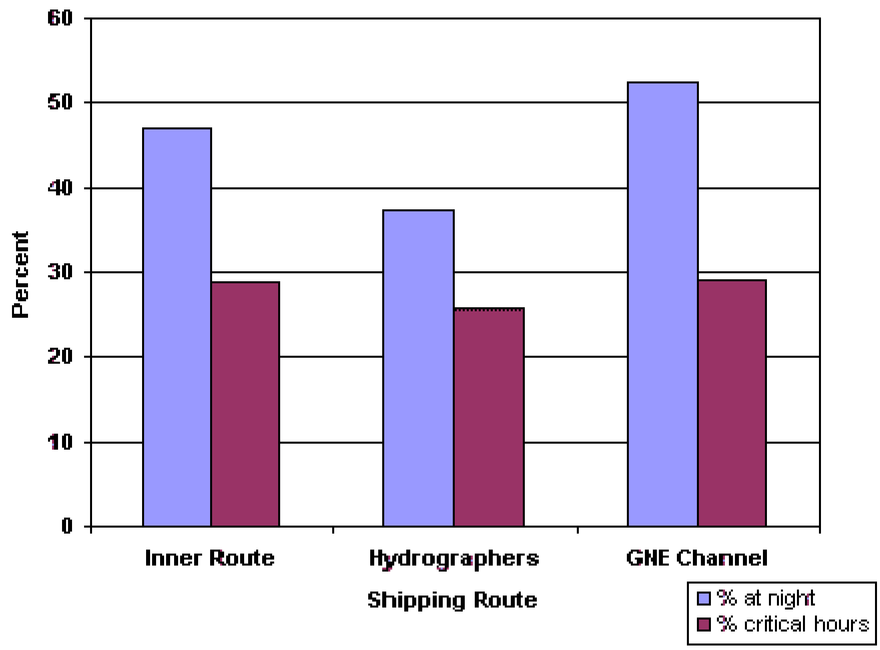


Figure 6.2 Mean percent of bridge time at night and during critical hours (2300-0600), by shipping route.

Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Percent of bridge time at night (1818-0525)				
Inner Route	n/a	46.91 (1.44)	0.27	=0.766
Hydrographers Passage	n/a	37.28 (6.08)		

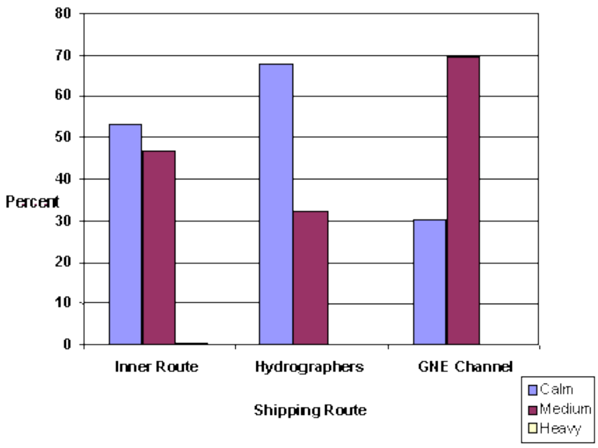
GNE Channel	n/a	52.47 (8.72)		
Percent of bridge periods in critical hours (2300-0600) Inner Route Hydrographers Passage GNE Channel	 n/a n/a n/a	 28.79 (5.63) 25.74(1.31) 28.96(6.56)	 0.02	 =0.982

1. Results of full two-way Analysis of Variance (ANOVA) model. p < 0.01 considered statistically significant. n/a = Post hoc testing not performed when main effects not significant

6.4 Sea conditions during Bridge Periods

Sea conditions were identified by the pilot advisory group as an important factor in determining the degree of difficulty associated with a particular assignment and with the potential to generate additional fatigue. To explore this issue respondents were asked to rate the sea conditions on the dimensions of calm (0-1.5 m), medium (1.5-5.4 m) or heavy (5.4-13.7 m). The data is based on records taken during 1074 bridge periods undertaken during the months of May and June, 1998. With the exception of the GNE Channel it is unlikely that the sea conditions would have contributed to additional stress and/or fatigue during bridgework. As shown in Figure 6.3, sea conditions for the Inner route and Hydrographers Passage were calm during more than 50 percent of bridge periods, with medium conditions experienced about 30 percent of the time. In contrast, in the GNE Channel, sea conditions were medium during 69 percent of bridge periods with calm conditions during 32 percent of bridge time. This difference was not unexpected given the relative exposure of this region compared with the more protected routes by virtue of their position within the Barrier Reef. On all shipping routes there was an absence of heavy sea conditions during the sampling period. Weather conditions may have been a more significant factor in fatigue had the data collection period coincided with the cyclone season between December and March.

Figure 6.3 Mean percent of bridge periods associated with calm, medium and heavy sea conditions, by shipping route.



7.0 Sleep at Sea

An earlier investigation involving GBR pilots revealed that the sleep of pilots at sea is highly compromised in terms of its quantity and quality (Parker et al., 1997). It was suggested that the poor sleep patterns reflected the irregularity of work schedules and the on call nature of a pilots work. The strong relationship which exists between sleep deficiencies and fatigue prompted a closer examination of the nature and extent of sleep during work assignments at sea. Results shown in the earlier sections of this report indicated that opportunities for sleep at sea are determined by work patterns on the bridge. This section provides further insight into sleep patterns at sea with reference to sleep quality and the relationship to measures of fatigue and potential recuperative value.

7.1 Total Time in bed and Total Sleep Time per 24 hours

As shown in Figure 7.0 when in bed, pilots were mostly asleep, however the duration of time in bed during a 24 hour period differed significantly across the three shipping routes (Table 7.0).

Similarly, pilots total sleep time per 24 hours displayed a shipping route effect with pilots averaging less sleep on the GNE Channel than on the other two routes (Table 7.0). When evaluated per 24 hours, pilots averaged one hour of sleep on the GNE Channel and 4 and 5 hours for Hydrographers Passage and the Inner Route, respectively. Logbook entries for sleep times per 24 hours for Hydrographers Passage and the Inner Route were very consistent with questionnaire responses in which pilots indicated they averaged about 5 hours sleep per day while working at sea (Parker et al., Report No 4, 1998). In terms of the GNE Channel, the average sleep per 24 hours was consistent with data shown previously (Section 6.2, Table 6.1) which indicated pilots spend almost all of the pilotage time on the bridge in this region.

Figure 7.0 Mean total time in bed and total sleep time per 24 hours at sea, by shipping route

Table 7.0 Analysis of the total time in bed and total sleep time per 24 hours at sea, by shipping route (1)

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Total time (hours) in bed per 24 hours				
Inner Route	1	6.19 (0.21)	29.51	<0.001
Hydrographers Passage	2	4.06 (0.79)		
GNE Channel	3	0.75 (0.30)		
Total sleep time (hours) per 24 hours				
Inner Route	1	5.25 (0.25)	18.60	<0.001
Hydrographers Passage	1	4.00 (0.74)		
GNE Channel	2	0.59 (0.30)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range test for post-hoc differences (Type 1 Error Rate = .01) $p < 0.01$ for differences between shipping routes from post-hoc

7.2 Duration of each Sleep Period and Number of Sleep Periods per 24 hours

Figure 7.1 reveals that sleep on the Inner Route was taken in multiple sleep periods, in contrast with the other routes when sleep was experienced in a single sleep period. As Table 7.1 shows there was a significant shipping route effect for the sleep period duration and the number of sleep periods per 24 hours. Each sleep period was significantly longer (4.6 hours) on Hydrographers Passage, than on either the Inner Route (1.97 hours) or the GNE Channel (1.03 hours). The number of sleep periods were significantly greater on the Inner Route than the other two routes (Table 7.1).

That sleep was taken during three separate periods on the Inner Route is consistent with the assignment duration and multiple bridge periods on this route.

Figure 7.1 Mean duration of each sleep period and number of sleep periods per 24 hours at sea, by shipping route.

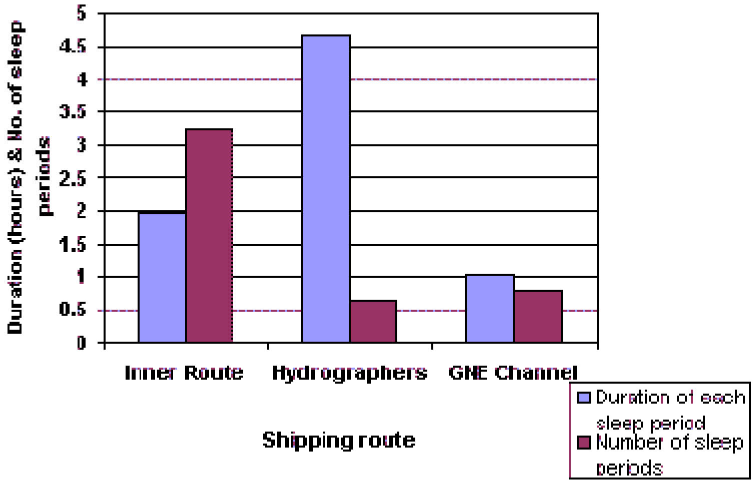


Table 7.1 Analysis of the duration of each sleep period and the number of sleep periods per 24 hours at sea, by shipping route (1)

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Duration (hours) of each sleep period Inner Route	1	1.97 (0.07)	16.47	<0.001
Hydrographers Passage	2	4.66 (0.68		
GNE Channel	1	1.03 (0.21)		
No. of sleep periods per 24 hours Inner Route	1	3.25 (0.12)	38.42	<0.001
Hydrographers Passage	2	0.65 (0.09)		
GNE Channel	2	0.79 (0.36)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range test for post-hoc differences (Type 1 Error Rate = .01); $p < 0.01$ for differences between shipping routes from post-hoc

7.3 Other Sleep Characteristics associated with Fatigue

Characteristics of sleep such as the time taken to fall asleep (sleep latency) and that taken to feel alert following sleep (sleep inertia) can also provide an indication of fatigue levels. Sleep latency has been shown to decrease following periods of restricted sleep, with a latency of 5 minutes or less being associated with a fatigued state. Similarly, the time taken to feel alert after waking tends to increase as a person becomes more fatigued (Roth et al., 1989).

There was no significant shipping route effect for either measure (Table 7.2). Sleep latency time ranged from 4 minutes on the GNE Channel assignments to 6 and 7 minutes for Hydrographers

Passage and the Inner Route, respectively. Thus the present sleep latency data was within or close to the classification of a fatigued state (Roth et al., 1989).

Table 7.2 also shows the percentage of sleep periods on each of the shipping routes with latencies of less than 5 minutes. Thirty eight and 31 percent of sleep periods met this criteria during assignments on the Inner Route and Hydrographers Passage, respectively. On GNE Channel assignments, 83 percent of sleep periods displayed sleep latencies of this duration. These findings suggested that the percent of sleep at sea with latencies < 5 minutes was higher for the GNE Channel, however the small number of sleep periods sampled on this route prevented statistical confirmation of this finding.

Sleep inertia represents a period of potential performance impairment that occurs immediately on waking. The time to feel alert ranged from 0.55 mins on the GNE Channel to 2 and 6 minutes for the Inner Route and Hydrographers Passage assignments, respectively and was not different between the shipping routes (Table 7.2). The short time taken to feel alert may be related to the on call nature of pilotage work and the associated apprehension which may counteract or mask any symptoms of sleep deprivation. Sleep inertia has been shown to be more severe for those in sleep deprived situations (Dinges, 1992), and continued sleepiness in non-sleep deprived subjects has been shown to last for 15 minutes with this time increasing in sleep deprived individuals (Haslam, 1982).

Sleep efficiency, defined as the percent of time in bed asleep was relatively high across all shipping routes (Table 7.2). This factor, coupled with the reduced sleep latency and little loss of sleep due to awakenings (Table 7.2), is consistent with a fatigued state.

Table 7.2 Analysis of other sleep characteristics associated with fatigue at sea, by shipping route (1)

Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Sleep latency (mins)				
Inner Route	n/a	7.23 (0.30)		
Hydrographers Passage	n/a	6.36 (1.50)		
GNE Channel	n/a	3.82 (1.56)		
Time (mins) to feel alert				
Inner Route	n/a	2.28 (0.32)		
Hydrographers Passage	n/a	6.14 (2.52)		
GNE Channel	n/a	0.55 (0.18)		
Percent of sleep periods with sleep latency < 5 mins				
Inner Route	n/a	38.88 (0.02)		
Hydrographers Passage	n/a	31.82 (0.10)		
GNE Channel	n/a	83.33 (0.16)		
Time (mins) lost due to awakenings				
Inner Route	n/a	3.20 (0.38)		
Hydrographers Passage	n/a	3.05 (1.67)		
GNE Channel	n/a	1.92 (0.86)		
Sleep efficiency				
Inner Route	n/a	90.25 (3.79)		

Hydrographers Passage	n/a	92.82 (1.71)		
GNE Channel	n/a	93.61 (3.55)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant. n/a = Post hoc testing not performed when main effects not significant

7.4 Timing of Sleep

Bridgework at sea determines not only the duration but also the timing of sleep. Sleep during physiologically appropriate times (2200-0800 hours) has the potential to be of greater recuperative value (Akerstedt, 1995; Kecklund et al., 1997).

7.4.1 Percent of sleep within 2200-0800 hours

As Figure 7.3 shows the percentage of sleep within these hours ranged from 50 to 81percent. A significantly higher percentage of sleep was taken within these hours on Hydrographers Passage (81 percent) compared with the Inner Route (50 percent), and Great North East Channel (59 percent) (Table 7.3). This finding reflects the need for shipping schedules on Hydrographers passage to coincide with port facilities and is consistent with the single bridge and sleep period reported previously. In contrast, the longer duration of Inner Route assignments and the greater number of bridge and sleep periods resulted in approximately half the sleep being taken outside of this optimal time period.

That 50 and 40 percent of sleep occurred outside optimal hours for the Inner Route and GNE Channel, respectively, raises further questions regarding the recuperative value of sleep of 1-2 hour duration to counteract fatigue while on the bridge in these regions, particularly on the longer Inner Route.

As the frequency distribution in Figure 7.4 shows approximately 20 percent of sleep starting times occurred across most of the hours in the 24 hour cycle (between midnight and 2200) which indicates that pilots are frequently required to sleep at sub-optimal times. A peak in sleep starting times occurred between the hours of 2000 and midnight on the three routes. However, previous sections have shown that it is likely that sleep beginning between these hours is inclined to be fragmented, particularly on the Inner Route.

Figure 7.2 Mean percent of sleep periods inside 2200-0800 at sea, by shipping route.

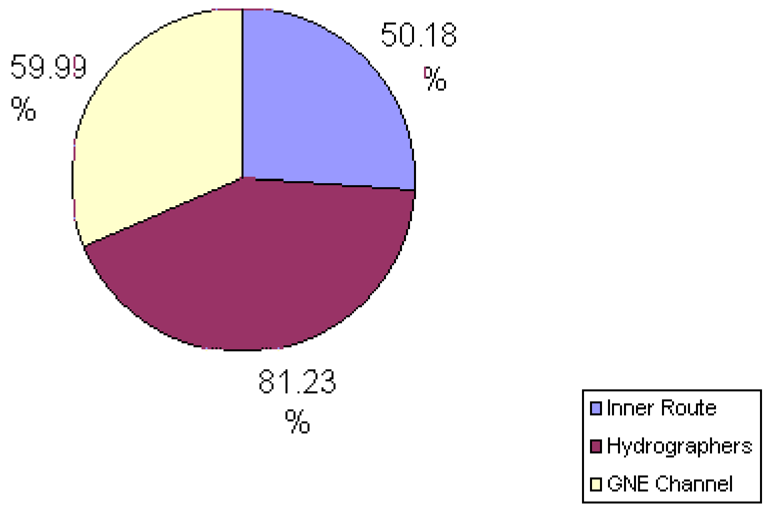
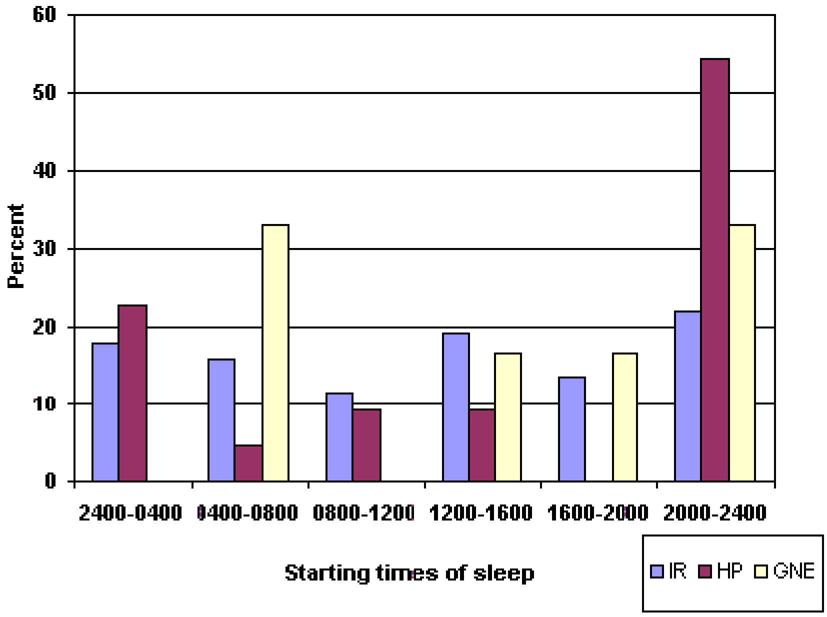


Table 7.3 Analysis of the percent of sleep periods inside 2200-0800 at sea, by shipping route (1)

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Percent of sleep inside 2200-0800				
Inner Route	1	50.18 (1.77)	25.31	<0.001
Hydrographers Passage	2	81.23 (8.37		
GNE Channel	1	59.99 (24.49)		

1. Results of full two-way Analysis of Variance (ANOVA) model. p < 0.01 considered statistically significant.
2. Results of Tukey's Studentised Range test for post-hoc differences (Type 1 Error Rate = .01) p < 0.01 for differences between shipping routes from post-hoc

Figure 7.3 Frequency distribution - starting times of sleep periods at sea, by shipping route.



7.5 Sleep Quality

Earlier sections of this report have indicated that sleep at sea is of short duration, sometimes fragmented and characterised by factors associated with fatigue such as short latency. Moreover, up to 50 percent of this sleep is outside optimal sleeping hours. This section includes measures which are indicative of the quality of sleep and represent the pilots perception with respect to; the ease of falling asleep, ease of arising, sufficiency of sleep, and feeling rested and depth of sleep. The sleep quality measure was determined from the sum of responses to scales for these measures (range 5-25), a higher score indicating better quality sleep.

Ratings of sleep quality were at the higher end of the sleep quality range and were similar across the different shipping routes (Figure 7.5) and (Table 7.4). This result suggests that the high sleep quality scores may indicate that the short and fragmented sleep at sea provided some restorative value. However, these ratings were inconsistent with previous sleep quality data on this group which showed that the majority of pilots experienced poor-very poor sleep (Parker et al., 1997). This discrepancy suggests that the pilots may have slightly overrated their sleep which is common when subjective assessments are used, particularly in occupational settings.

Figure 7.4 Sleep quality ratings at sea, by shipping route

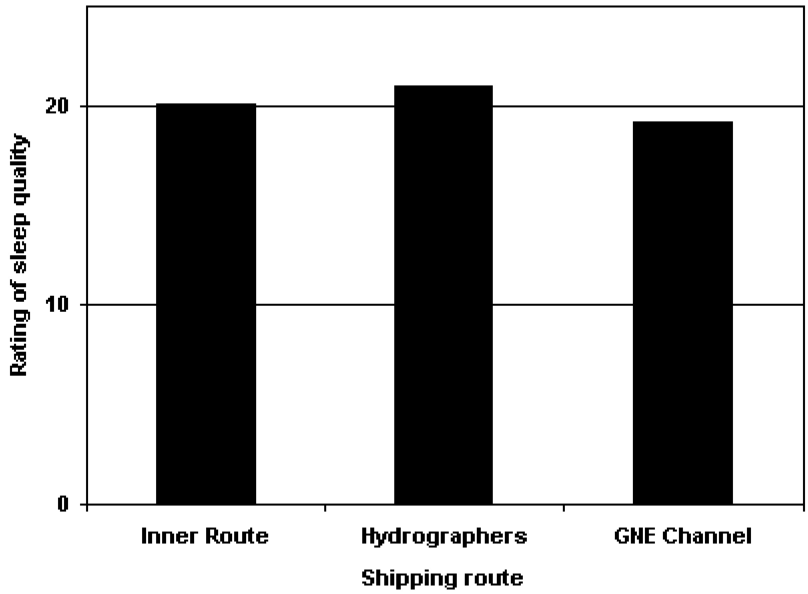


Table 7.4 Analysis of sleep quality ratings at sea, by shipping route (1)

Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Rating of sleep quality				
Inner Route	n/a	20.08 (0.14)	2.39	=0.092
Hydrographers Passage	n/a	21.00(0.90)		
GNE Channel	n/a	19.17(1.76)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant. n/a = Post hoc testing not performed when main effects not significant

7.6 Sleep Debt

Sleep debt is defined as the difference in the duration of home sleep and sleep in another location. As Table 7.5 shows, earlier estimates of sleep debt at sea in this population indicated a daily debt of 2.3 hours (Parker et al., Report No 4, 1998).

When compared with sleep ashore during assignment breaks, logbooks indicated pilots experienced a daily sleep debt of 5.7 and 6 hours for the Inner Route and Hydrographers Passage, respectively. (Table 7.6). When compared with sleep at home, logbook daily sleep debt for both these shipping routes was approximately 3 hours. Hence, whether sleep debt at sea is based on at home, or ashore sleep hours it is a greater problem on longer Inner Route assignments where the sleep debt is incurred over several days.

Table 7.5 Questionnaire responses: sleep patterns at home, ashore and at sea.

Mean sleep duration (hours) per 24 hours at Home	Mean sleep duration (hours) per 24 hours ashore	Mean sleep duration (hours) per 24 hours at sea	Daily sleep debt (hours)
7.8 (0.29)	8.0 (0.35)	5.5 (0.38)	2.3 hours (home –sea)

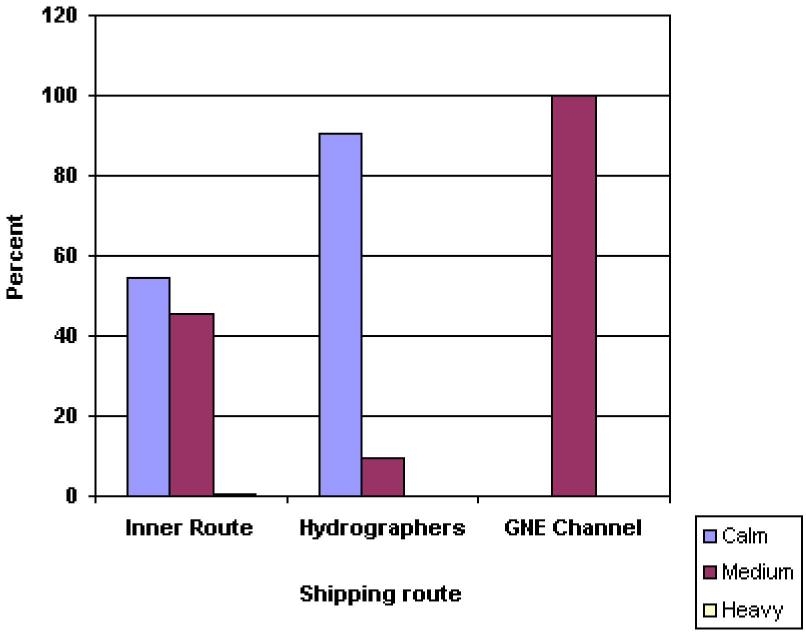
Table 7.6 Logbook responses: sleep patterns at sea and ashore, by shipping route.

Sleep duration per 24 hours	Inner Route	Hydrographers Passage
Total sleep time (hours) ashore before assignments on shipping routes	10.99	10.06
Total sleep time at sea	5.25	4.00
Sleep debt per 24 hours	5.74	6.06

7.7 Sea conditions during sleep

The results indicated that it was unlikely that sleep at sea was affected to any degree by sea conditions. For instance, as indicated by Figure 7.4 on the Inner Route approximately 50 percent of sleep periods were associated with calm or medium sea conditions. During Hydrographers Passage pilotages 90 percent of sleep was associated with calm conditions. In contrast, all sleep periods on the GNE Channel assignments were associated with medium sea conditions. That sea conditions in this latter region during the more stable winter months were medium is consistent with the relative exposure of the region to prevailing weather patterns compared with the other shipping routes.

Figure 7.5 Mean percent of sleep periods with calm, medium or heavy sea conditions, by shipping route



8.0 Sleep ashore between Assignments

During a tour of duty GBR pilots alternate between working on ships and spending time ashore resting between each assignment. Breaks ashore present the opportunity for pilots to recuperate from the previous pilotage and prepare themselves for the next assignment. This section provides some understanding of the sleep patterns during breaks and evaluates the type of sleep experienced prior to undertaking the next assignment.

8.1 Accommodation Type while ashore

Table 8.0 shows the frequency by which a particular type of accommodation is used when ashore during assignment breaks. Thirty-three percent of assignment breaks were spent in pilot accommodation with 28 percent and 30 percent spent at home and in hotels/motels, respectively. Thus 63 percent of breaks are spent in alternate accommodation. Pilots who reside at home during assignment breaks are those who live (in coastal towns in northern and central Queensland) in close proximity to the operational regions.

Table 8.0 Type of accommodation ashore between assignments

Location	Percent
At home	27.9
Pilot accommodation	33.3
Hotel/motel	30.0
Other	8.8

8.2 Total time in bed and sleep time per 24 hours

While ashore, most of the time pilots were in bed they were asleep (Figure 8.0). Table 8.1 reveals no shipping route effect on either total time in bed or total sleep time ashore. Total sleep time ashore ranged from 9 hours prior to GNE Channel assignments to 10 and 11 hours prior to work on Hydrographers Passage and the Inner Route, respectively (Table 8.1).

Figure 8.0 Mean total time in bed and total sleep time per 24 hours ashore, by shipping route

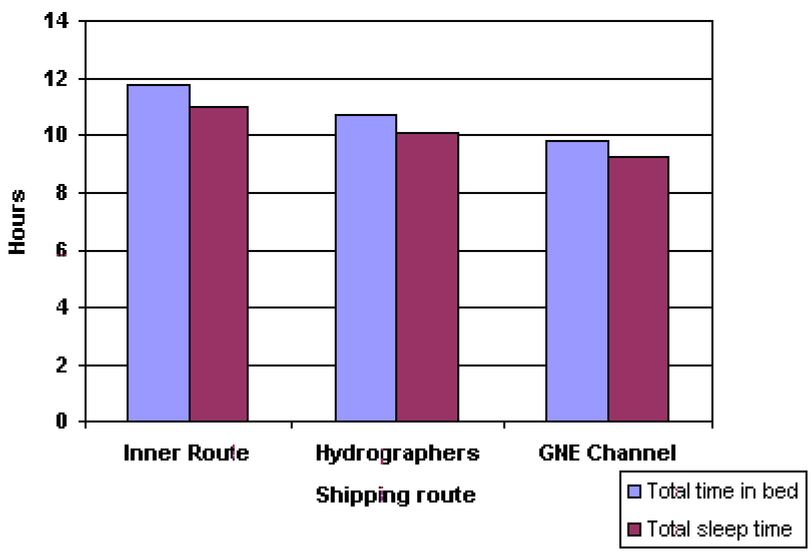


Table 8.1 Analysis of the total time in bed and total sleep time per 24 hours ashore, by shipping route (1) *

Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Total time (hours) in bed per 24 hours				
Inner Route	n/a	11.77 (1.20)	0.93	= 0.399
Hydrographers Passage	n/a	10.72 (1.24)		
GNE Channel	n/a	9.82 (0.81)		
Total sleep time (hours) per 24 hours				
Inner Route	n/a	10.99 (1.21)	0.50	= 0.606
Hydrographers Passage	n/a	10.06 (1.10)		
GNE Channel	n/a	9.27 (0.89)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant. n/a = Post hoc testing not performed when main effects not significant

*Shipping route for ashore sleep data refers to the route of the next assignment

Shore sleep data assessed on 165 of 176 assignments – only for breaks of 3 days or less.

8.3 Duration of each sleep period and number of sleep periods per 24 hours

In terms of the total sleep duration per 24 hours pilots' sleep approximated more conventional sleeping hours. This section provides some insight into the patterning of pilots sleep. Logbook data indicated while ashore, sleep was generally taken in one sleep period, (occasionally more than one) averaging 7 hours (Figure 8.1). Neither the duration nor number of sleep periods differed displayed a shipping route effect (Table 8.2). This result indicated that total sleep ashore of between 9 and 11 hours consisted of one sleep of approximately 7 hours with an additional sleep of 2-3 hours. Given that pilots often undertake travel between ports during assignment breaks the additional short sleep period may be related to travel and/or the timing of sleep across the break.

Figure 8.1 Mean duration of each sleep period and number of sleep periods per 24 hours ashore, by shipping route

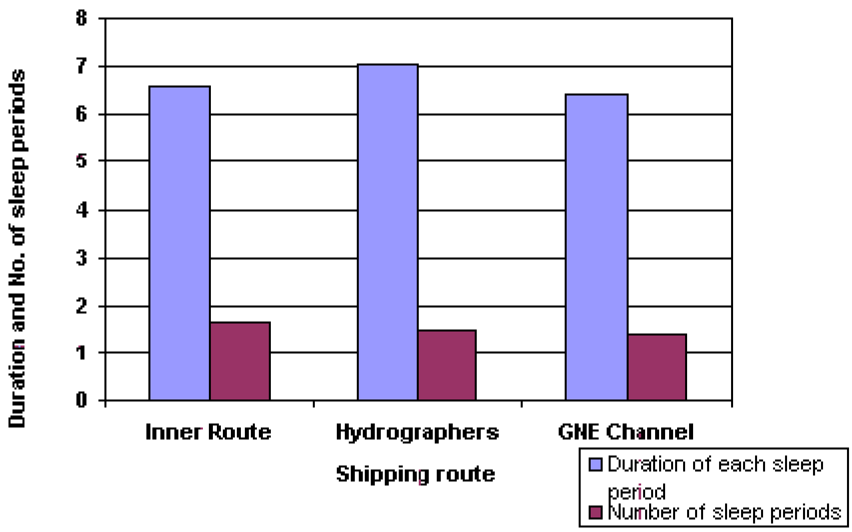


Table 8.2 Analysis of the duration of each sleep period and the number of sleep periods per 24 hours ashore, by shipping route (1) *

Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Duration (hours) of each sleep period				
Inner Route	n/a	6.60 (0.17)	0.17	=0.847
Hydrographers Passage	n/a	7.06 (0.36)		
GNE Channel	n/a	6.42 (0.44)		
No. of sleep periods per 24 hours				
Inner Route	n/a		0.87	=0.462
Hydrographers Passage	n/a			
GNE Channel	n/a			

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant. n/a = Post hoc testing not performed when main effects not significant

*Shipping route for ashore sleep data refers to the route of the next assignment

Shore sleep data assessed on 165 of 176 assignments – only for breaks of 3 days or less.

8.4 Other sleep characteristics associated with Fatigue

A further understanding of fatigue levels was provided by the analysis of data on the time taken to fall asleep (sleep latency) and the time to feel alert. Sleep latency ranged between 6 and 8 minutes and was similar prior to assignments on the three shipping routes (Table 8.3).

Further analysis showed a similar proportion of sleep prior to assignments with latencies under 5 minutes on the three shipping routes. That a considerable percent of this sleep approximated a fatigued state suggested, despite sleeping out of normal physiological sleeping times and in alternate accommodation, pilots were tired and fell asleep quickly.

Table 8.3 also reveals that while ashore pilots took between 9 and 17 minutes to feel alert. This figure was double the time taken to feel alert at sea.

The relatively high sleep efficiency scores of 93 percent (Table 8.3) are consistent with data above indicating that most of the time pilots were in bed, they were asleep (Table 8.0). That 63 percent of breaks were spent in alternate accommodation may have contributed to pilots losing between 7 and 10 minutes of sleep due to awakenings (Table 8.3).

Table 8.3 Analysis of other sleep characteristics associated with fatigue ashore, by shipping route (1) *

Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Sleep latency (mins)				
Inner Route	n/a	7.80 (0.91)	0.10	=0.905
Hydrographers Passage	n/a	6.62 (1.12)		
GNE Channel	n/a	5.65 (1.11)		
Time (mins) to feel alert				
Inner Route	n/a	15.14 (5.11)	0.39	= 0.674
Hydrographers Passage	n/a	9.08 (3.43)		
GNE Channel	n/a	17.23 (6.07)		
Percent of sleep periods with sleep latency < 5 mins				
Inner Route	n/a	37.11(2.84)	1.0	=0.369
Hydrographers Passage	n/a	42.59 (6.79)		
GNE Channel	n/a	52.77 (7.61)		
Time (mins) lost due to awakenings				
Inner Route	n/a	6.71 (0.81)	0.31	= 0.733

Hydrographers Passage GNE Channel	n/a n/a	10.29 (2.02) 7.47 (2.65)		
Sleep efficiency Inner Route Hydrographers Passage GNE Channel	 n/a n/a n/a	 92.50 (0.64) 93.78 (1.06) 93.91 (2.58)	0.69	= 0.504

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant. n/a = Post hoc testing not performed when main effects not significan

* Shipping route for ashore sleep data refers to the route of the next assignment

Shore sleep data assessed on 165 of 176 assignments – only for breaks of 3 days or less.

8.5 Timing of sleep

From the results thus far while ashore, pilots' sleep approximates normal sleeping habits in terms of the total sleep and patterning. However, sleep timing ashore and therefore its duration and potential recuperative value is determined by the starting times of breaks. Given that earlier sections revealed that the starting times of breaks ashore displayed a fairly rectangular distribution across the 24 hour cycle a closer examination of logbook data on the percent of sleep during optimal hours (2200-0800) was undertaken.

8.5.1 Percent of sleep inside 2200-0800 hours

Approximately 83 percent of sleep was within this time during breaks prior to Hydrographers Passage assignments, with 73 percent of sleep meeting this criteria prior to work on the Inner Route and GNE Channel (Figure 8.2). There was no significant shipping route effect (Table 8.4). Conversely, these findings also indicated that between 20 and 30 percent of sleep was outside optimal hours prior to work on the three shipping routes. These data suggested that during a percentage of breaks the duration and/or timing of the break did not allow for sleep to occur during optimal sleeping periods. Thus sleep may not provide sufficient recuperative value to diminish fatigue accumulated during work at sea.

The distribution of sleep starting times (Figure 8.3) shows that 60-70 percent of sleep ashore began between the hours of 2000 and midnight prior to assignments on each of the shipping routes; the remainder of sleep periods were fairly evenly distributed between midnight and 2000.

Figure 8.2 Mean percent of sleep inside 2200-0800 ashore, by shipping route

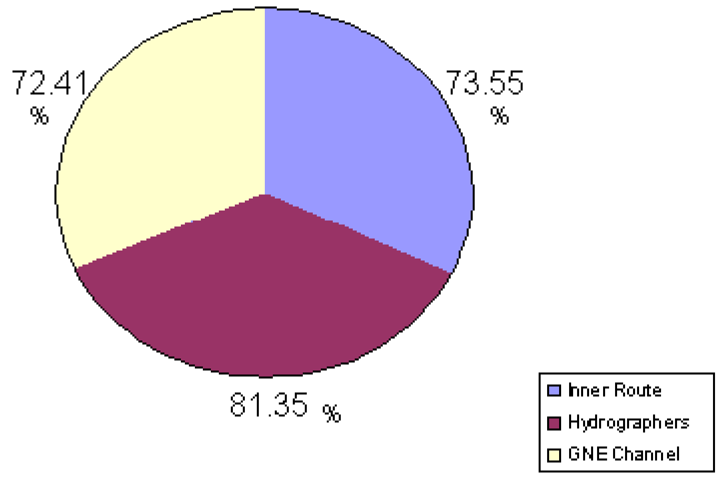


Table 8.4 Analysis of the percent of sleep periods inside 2200-0800 ashore, by shipping route(1) *

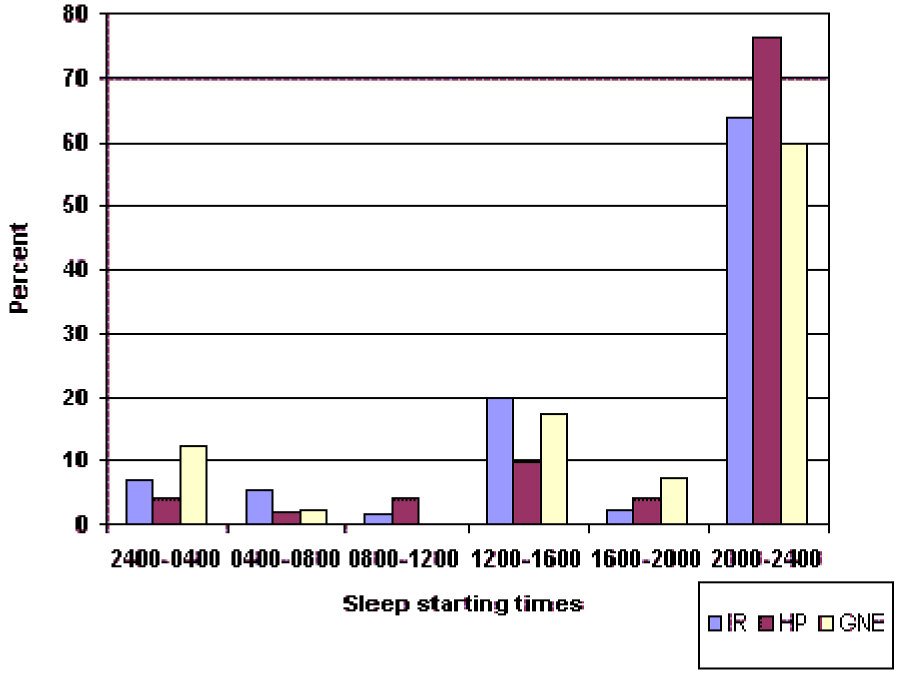
Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Percent of sleep inside 2200-0800				
Inner Route	n/a	73.55 (2.44)	0.21	= 0.810
Hydrographers Passage	n/a	81.35 (4.74)		
GNE Channel	n/a	72.41 (6.28)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant. n/a = Post hoc testing not performed when main effects not significant

* Shipping route for ashore sleep data refers to the route of the next assignment

Shore sleep data assessed on 165 of 176 assignments – only for breaks of 3 days or less

Figure 8.3 Frequency distribution - starting times of sleep ashore, by shipping route.



8.6 Sleep Quality

Sleep quality ashore was determined using identical procedures to those described for assessing sleep quality at sea (Section 7.6). As Figure 8.4 shows sleep quality ratings ranged between 19 and 22 and were towards the higher end of the sleep quality scale (range 5-25). The significant shipping route differences in sleep quality related to the higher sleep quality reported prior to Inner Route assignments, compared with sleep quality values prior to work on the other two shipping routes (Table 8.5). There is a possibility that the higher sleep quality scores indicated sleep ashore was recuperative; however, that between 20-30 percent of this sleep is opposed to normal physiological sleeping times and taken in pilot accommodation and hotels raised some doubt over the validity of the high sleep quality ratings. As with sleep quality at sea, it is likely that sleep quality was over rated.

Figure 8.4 Sleep quality ratings ashore, by shipping route

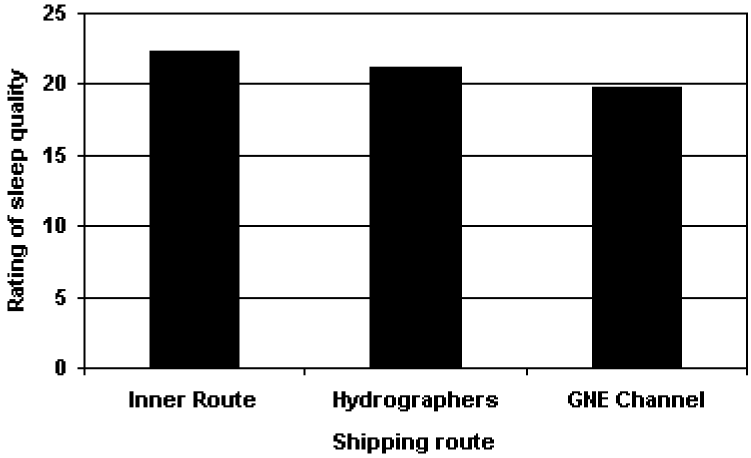


Table 8.5 Analysis of sleep quality ratings ashore, by shipping route1 *

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Rating of sleep quality				
Inner Route	1	22.37(0.18)	5.89	=0.003
Hydrographers Passage	2	21.18(0.55)		
GNE Channel	2	19.72(0.61)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range test for post-hoc differences (Type 1 Error Rate = .01) $p < 0.01$ for differences between shipping routes from post-hoc

* Shipping route for ashore sleep data refers to the route of the next assignment

Shore sleep data assessed on 165 of 176 assignments – only for breaks of 3 days or less

Results: ALERTNESS AND FATIGUE DURING BRIDGEWORK

9.0 Measures of Alertness and Fatigue during Bridgework

Ratings of alertness and the presence of fatigue symptoms were recorded to assess performance decrements during bridge periods. Both measures were highly relevant to the present investigation given that previous research had found high correlations between self reports of alertness and/or sleep loss and measures of performance (Gillberg, et al., 1994). The onset of fatigue symptoms such as slow eye movements correspond with alertness ratings in the lower end of the scale (Akerstedt & Folkard, 1995).

9.1 Alertness Ratings during Bridgework

One aim of the logbooks was to explore any fluctuations in alertness during the course of bridgework. Alertness was scored on a visual analogue scale (range: very sleepy, to very alert; score 1-9). Pilots average alertness during bridge periods ranged from 6.2-7.7, that is, towards the higher end of the scale (Figure 9.0). There was no significant shipping route effect on alertness during bridge periods (Table 9.0), and alertness did not fluctuate significantly across the duration of bridge periods.

Given that earlier results identified that work on Hydrographers Passage was less demanding it is not surprising that alertness ratings were marginally higher during bridge periods on Hydrographers Passage compared with the other two shipping routes (Figure 9.0). The overall trend in alertness during bridge periods was distinctly different between the shorter routes (Hydrographers Passage and the GNE Channel) and the longer Inner Route (Figure 9.0). However, at the three hour point on both shipping routes, that is, at the end of the bridge period on the longer route, and midway through the longer bridge periods (6-7 hours) there was a decrease in alertness (Figure 9.0).

To further examine the fatigue issue the percentage of bridge periods with minimum alertness ratings were assessed. Alertness ratings of 3 or less are associated with sleepiness. Three percent of bridge periods on Hydrographers Passage met this criteria with the figure rising to 8 and 12 percent for the Inner Route and GNE Channel, respectively (Figure 9.1). The lower percent of bridge periods associated with minimum alertness on Hydrographers Passage is also consistent with the less demanding work patterns in this region. The data suggested that the percent of bridge periods with minimum alertness was higher for GNE Channel assignments; however, there was insufficient data collected on this route to confirm this statistically (Table 9.0).

Figure 9.0 Fluctuations in alertness during bridgework, by shipping route

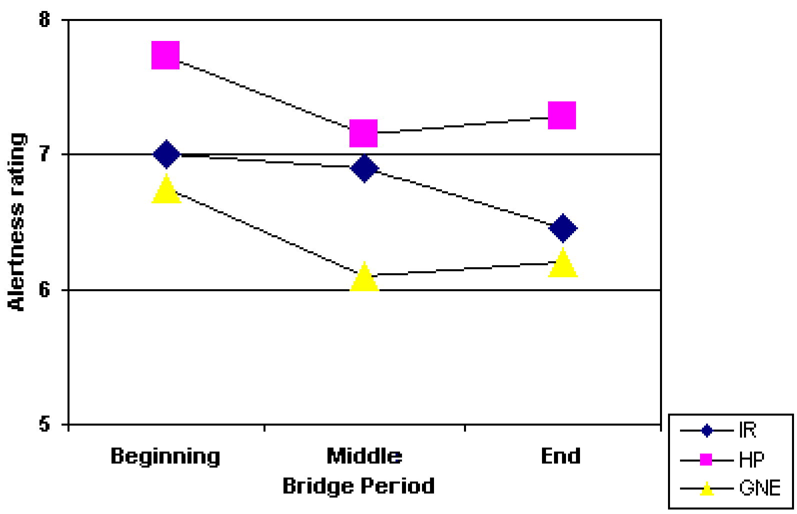


Figure 9.1 Mean percent of bridge periods with alertness ratings < 3, by shipping route.

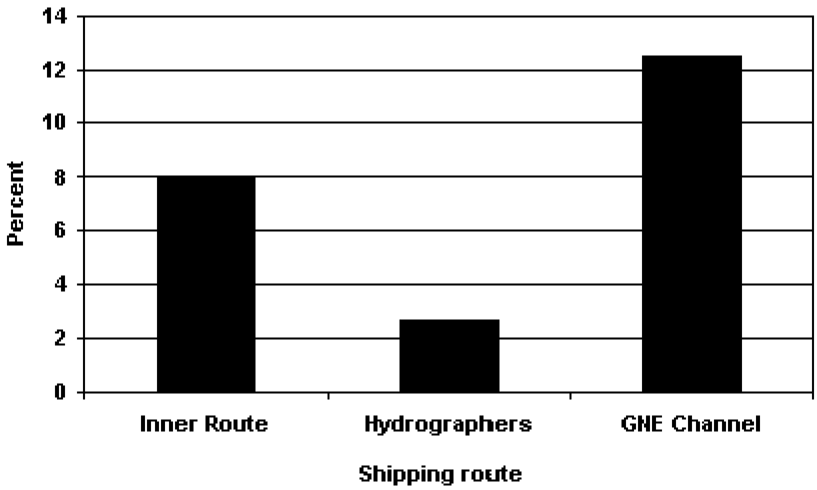


Table 9.0 Analysis of alertness ratings during bridge periods, by shipping route (1)

Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Alertness ratings for the beginning of bridge periods				
Inner Route	n/a	7.01 (0.05)	2.11	= 0.120
Hydrographers Passage	n/a	7.73 (0.14)		
GNE Channel	n/a	6.75 (0.32)		
Alertness ratings for the middle of bridge periods				
Inner Route	n/a	6.90 (0.06)	1.25	= 0.288
Hydrographers Passage	n/a	7.16 (0.20)		
GNE Channel	n/a	6.75 (0.30)		
Alertness ratings for the end of bridge periods				
Inner Route	n/a	6.46 (0.06)	0.80	= 0.449
Hydrographers Passage	n/a	7.29 (0.21)		
GNE Channel	n/a	6.21 (0.37)		
Percent of bridge periods with alertness ratings < 3				
Inner Route	n/a	7.9 (0.13)	0.25	= 0.78
Hydrographers Passage	n/a	2.6 (0.23)		
GNE Channel	n/a	12.5 (0.41)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant. n/a = Post hoc testing not performed when main effects not significant

9.2 Number of Fatigue Symptoms during Bridgework

To further assess the presence of fatigue during bridgework the number of fatigue symptoms were calculated. The number of fatigue symptoms during bridge periods ranged from 1 on Hydrographers Passage to 3 on both the Inner Route and GNE Channel (Figure 9.2). The significant shipping route effect was related to the greater number of symptoms experienced during bridge periods on the Inner Route and GNE Channel than on Hydrographers Passage (Table 9.1). This finding is consistent with the work assignment characteristics indicating work on these routes is more demanding than work on Hydrographers Passage and the slightly higher bridge alertness displayed for this route (Section 9.1).

Respondents were also required to rate the degree to which fatigue symptoms were experienced on a seven point Likert scale ranging from 'not at all' (scale = 1) to 'very much' (scale =7). The sum of the scores (range 10-70) was calculated, a higher score indicating symptoms were experienced to greater degree.

As Table 9.2 indicates the sum of the scores ranged between 12 and 17 and were at the lower end of the range. The significant shipping route effect related to the higher scores reported for the Inner Route and GNE Channel. This is also consistent with greater demands on pilots in these regions and the number of fatigue symptoms reported above.

Figure 9.2 Mean number of fatigue symptoms experienced during bridge periods, by shipping route.

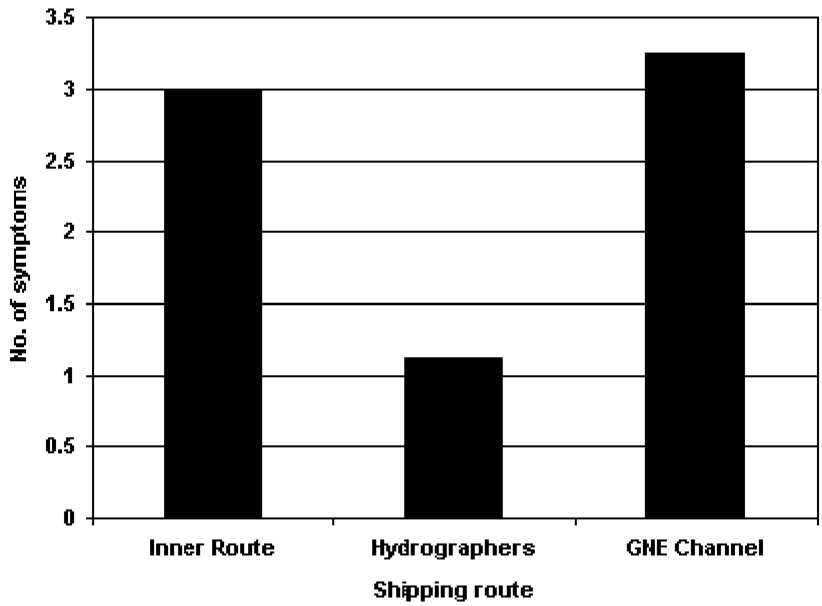


Table 9.1 Analysis of fatigue symptoms during bridge periods, by shipping route (1)

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
No. of symptoms of fatigue/10				
Inner Route	1	3.00 (0.09)	6.33	=0.001
Hydrographers Passage	2	1.13 (0.21)		
GNE Channel	1	3.25 (0.67)		

Sum of scores of fatigue symptoms (Range 10-70) Inner Route Hydrographers Passage GNE Channel	 1 2 1	 14.41 (0.21) 11.78 (0.35) 16.91 (1.64)	 4.46	 =0.001

1. Results of full two-way Analysis of Variance (ANOVA) model. p < 0.01 considered statistically significant.
2. Results of Tukey's Studentised Range test for post-hoc differences (Type 1 Error Rate = .01) p < 0.01 for differences between shipping routes from post-hoc

9.3 Percent of Bridge Periods with one of more Fatigue Symptoms

From the number of fatigue symptoms presented above, the percentage of bridge periods with one or more symptoms of fatigue was calculated. On the Inner Route and Hydrographers Passage, 58 percent of bridge periods were associated with one or more fatigue symptoms with the percentage rising to 83 for the GNE Channel (Figure 9.3). The mean scores suggested that the percentage of bridge periods within this classification of symptoms was higher for the GNE Channel, however, there was inadequate data collected on this route for the result to be confirmed statistically.

The similar percentage of bridge periods on the Inner Route and Hydrographers showing one or more fatigue symptoms is unexpected given that significantly more fatigue symptoms were reported for the Inner Route than Hydrographers Passage (3 vs 1). However, a closer inspection of this result showed that the similar percentage of bridge periods meeting this criteria is due to the fewer assignments recorded on Hydrographers and thus resulting in a higher percentage. The presence of fatigue symptoms in spite of high alertness ratings suggested that alertness was slightly over rated by the respondents.

Figure 9.3 Mean percent of bridge periods associated with one or more symptoms of fatigue, by shipping route

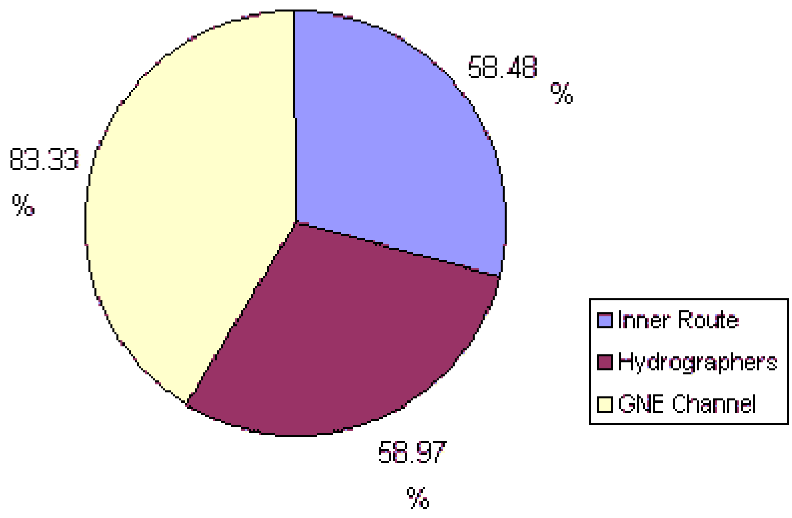


Table 9.2 Analysis of the percent of bridge periods with one or more symptoms of fatigue, by shipping route (1)

Effect	Post hoc results	Mean (sem)	F Statistics	p-value
Percent of bridge periods with one or more fatigue symptoms				
Inner Route	n/a	58.48 (1.56)	1.29	= 0.275
Hydrographers Passage	n/a	58.97 (7.98)		
GNE Channel	n/a	83.33 (7.77)		

1. Results of full two-way Analysis of Variance (ANOVA) model. $p < 0.01$ considered statistically significant. n/a = Post hoc testing not performed when main effects not significant.

10.0 Factors associated with high Fatigue levels and low alertness levels on the Bridge

10.1 Predictors of Fatigue, Stress and Alertness levels on the Bridge

The results in the preceding sections of this report based on the analyses of logbooks, and findings from other data sources, particularly the work schedules (Parker et al., Report No 2, 1998) indicated the presence of several key measures associated with decreased alertness and increased fatigue. In light of these findings an initial step was taken to predict fatigue, stress and alertness during bridge work from several key variables identified from work and break patterns. Thus the aim of this section was to identify features of work and break patterns which are correlated with high fatigue and low alertness.

To explore this issue a series of multiple linear regression models were used to assess contributions to variation in mean overall fatigue, stress, and minimum alertness measures of pilot data reflecting ashore and at-sea variables. After accounting for individual pilot variation, five incremental levels of modelling were attempted. Each level evaluated a set of data at a higher level of data refinement. Each additional level of modelling considered the percentage of additional variation in fatigue, stress, and alertness accounted for by a number of predictor variables associated with work and break patterns (Table 10.0). The multiple regression models considered individual subject average ratings of fatigue and stress over all time spent on the bridge and considered the minimum alertness level during the whole bridge period.

As Table 10.0 shows, individual differences in pilots accounted for substantial variation in the fatigue, stress and alertness scores. This individual pilot variability may be composed of physiological and other personal and environmental differences not considered in this study, which restricted itself to work- and break-related determinants of fatigue, stress, and alertness on the bridge.

The percentage of variation accounted for by individual differences may not be related to genuine differences in fatigue. There are two alternative explanations for the high of variance attributed to differences between pilots. The first is that pilots may differ in the use of rating scales in terms of central tendency and dispersion, thus these subjective rating scales cannot be used to make comparisons across, rather than within individuals. The second relates to negative effect evidence in the literature, that is, some individuals complain about everything, others about nothing.

After accounting for pilot differences, the two major contributing factors to all three outcomes were the duration of breaks preceding assignments and the duration of the actual assignment.

Break duration before an assignment was confirmed to substantially contribute to fatigue, stress and alertness during bridgwork. It is notable that this factor accounted for relatively more of the remaining variance in alertness than to either fatigue or stress (Table 10.0). This finding provided further evidence of the importance of rest break duration prior to assignments to ensure optimal alertness on the bridge.

Work assignment duration was the other major contributor to fatigue, stress and alertness on the bridge (Table 10.0). This factor accounted for 14 and 23 percent of the remaining variation in fatigue and stress, respectively; and 4 percent of the remaining variation in alertness. A qualitative assessment suggests that the time spent on assignment is a relatively greater contributor to stress on the bridge; whereas the duration of the break before an assignment contributed to a greater degree (13.3 percent) of the remaining variation in bridge alertness. As Table 10.0 indicates about 90 percent of the variation in all three outcomes was explained by accounting for individual pilot differences, total break and work assignment duration.

None of the other variables involving travel, bridgework or sleep at sea and ashore accounted for more than 2.5 percent of the remaining variation. That travel contributed only slightly, but marginally more to fatigue and stress is consistent with earlier results relating to the impact of travel on assignment stress. The more direct effects of travel may have been diluted due to the adjustment for travel in work assignment and break duration. There was also a suggestion that the total duration of bridge periods per assignment and the number of critical hours spent on the bridge contributed relatively more to alertness than to stress or fatigue (Table 10.0).

Results of the modelling procedures indicated that if additional data were collected to enhance the present reporting system for evaluating fatigue, stress and alertness on the bridge, it should at least recognise the individual differences in pilots' thresholds for coping with fatigue, stress, and alertness, and include data on work assignment and break duration and the total duration of bridge periods during an assignment and during critical hours. Future research should consider further refinement of these models to include more detailed temporal aspects of work and break patterns to enable changes in fatigue, stress and alertness during bridgework to be predicted for each additional hour of duty. Additionally, further development of the models will also consider that the potential non-linear relationship between fatigue/alertness and both break and work assignment duration. It is likely that the multiple regression modelling based on linear relationships may have underestimated the contribution to the variance in the outcomes of work assignment and break duration.

Table 10.0 Percentage of variation in overall fatigue, stress, and minimum alertness accounted for by measuring various levels of data about work and break patterns based on Inner Route data.

	FATIGUE	STRESS	ALERTNESS
Percent of variation accounted for by :			
Pilot differences	75.2	63.6	72.5
Duration of preceding break	82.2	69.5	85.8
(an increase of)	(7.0)	(5.9)	(13.3)
PLUS			
Total travel hours to/from ship	83.5	71.5	85.8
(an increase of)	(1.3)	(2.0)	(0.0)
PLUS			
Duration of work assignment	97.2	94.8	90.1
(an increase of)	(13.7)	(23.3)	(4.3)
PLUS			
Duration of pilotage time on assignment	97.3	94.9	90.2
(an increase of)	(0.1)	(0.1)	(0.1)
PLUS			
Average duration of bridge periods per assignment	97.9	96.6	92.6
(an increase of)	(0.6)	(1.7)	(2.4)
PLUS			
Average number of bridge periods per 24 hours	98.3	97.1	93.7
(an increase of)	(0.3)	(0.1)	(0.2)
PLUS			
Total duration of time in bed during assignment	98.3	97.4	93.9
(an increase of)	(-0.3)	(0.2)	(0.0)
PLUS			
Number of critical hours spent on the bridge	98.8	97.5	95.3
(an increase of)	(0.5)	(0.1)	(1.4)
PLUS			
Total duration of sleep during preceding break	99.1	97.6	95.7
(an increase of)	(0.3)	(0.1)	(0.4)
PLUS			

Total duration of non-critical sleep during break	99.6	98.0	95.7
(an increase of)	(0.5)	(0.4)	(0.0)

11.0 Discussion

Fatigue is a complex phenomenon that is difficult to define (Brown, 1994; Cameron, 1974; Parker et al.,1995) and generally presents as feelings of weariness and/or an aversion to continue with the activity. It encompasses both physical and psychological components and may be acute, chronic or both in nature. Many factors can contribute to the development of a fatigued state including poor general health, anxiety, apprehension, inadequate sleep and or poor nutrition. Inappropriate workloads, in either physical or mental tasks, or inappropriate work to rest ratios can lower a persons level of arousal (Grandjean, 1970; Parker et al., 1995) and exposure to specific environmental conditions such as noise, vibration and extreme temperatures may also induce fatigue. These factors may act independently or in combination with one another and while the above list is by no means exhaustive, it identifies many of the circumstances associated with the work of GBR pilots (Parker et al., 1997).

An earlier survey of the health, stress and fatigue of Australian seafarers (Parker et al., 1997) identified a number of factors, such as reduced length and poor quality of sleep at sea, which have the potential to induce fatigue. Relatively high levels of stress and some evidence of cardiovascular risk factors reported by pilots in the survey provided further evidence of the potential for fatigue in this group. Recent changes in the maritime industry and particularly the introduction of competition in pilotage operations were also seen as significant sources of stress and as having the potential to impact on safety. These findings coupled with increasing recognition of the role of fatigue in vessel incidents on the Barrier Reef provided the background to the initiation of a series of research projects designed to investigate those aspects of the work practices of GBR pilots that may potentiate fatigue.

Following an extensive review of the literature related to this research a retrospective analysis of work and rest schedules over an 18 month period was conducted. The analysis was based on information reported by pilots working for the 3 pilotage companies operating in the Great Barrier Reef/ Torres Strait region (Parker et al., Report No 2, 1998). The results indicated that pilotage work was characterised by irregular work and break patterns with work-related travel impacting significantly on assignment and break time. Significant differences between the companies were evident in the number of work assignments performed and in all companies workloads increased markedly during the months between July and December. Moreover, a considerable number of situations were identified where personnel undertook greater workloads and shorter breaks than depicted by average company figures.

These findings were enhanced by a more detailed survey of the general work practices of GBR pilots and their perception of aspects of their work and lifestyle which may have a bearing on fatigue (Parker et al., Report No 4, 1998). The findings indicated that the compromised sleep patterns at sea occurred as a function of the irregularity of the work and rest schedules, relatively long periods of sustained work, often at night and the necessity to work and sleep at times incompatible with the normal biological rhythms of the body. Pilots experienced fatigue particularly at the end of assignments and identified boredom, lack of sleep and high workloads as important contributing factors. The potential for a decrement in performance was further substantiated by difficulty experienced by some pilots in maintaining concentration and attention.

The final phase of the research which is the basis of this report aimed to investigate the relationship between specific work and sleep characteristics and measures of alertness during bridgework. This required pilots to record information during their work assignments and during break periods, in a log book which was similar to that used in studies of mariners in the US and UK (Sanquist et al., 1996; Seafarers International Research Centre, 1996). The logbook was modified following extensive consultation with the Pilot Advisory Group, to take account of the specific work characteristics of GBR pilots. The information included the extent and quality of sleep at sea and ashore, industry specific measures relating to the difficulty of the assignment and pilot ratings of alertness. Such ratings of alertness have been shown to have a significant relationship to performance (Gillberg et al., 1994) and this form of data collection frequently used in field settings, was considered to cause minimal disturbance of the pilot's work schedule. As the 3 routes in which pilots operate are associated with different work schedules and degrees of difficulty, the analyses were designed to contrast any differences which may exist between the work and rest patterns as a function of the routes.

11.1 Demographics

Pilotage services in the Barrier Reef region are supplied by a workforce of 58 pilots operating in three competing pilotage companies. The pilots represented a relatively older (mean age 53.2 + 1.64 years) stable, and highly experienced workforce. They had an average of 36 years of maritime service and 9.5 years in Barrier Reef pilotage. From the data sources it was evident that the size of the workforce and fluctuations in work availability, particularly the seasonal impact, placed demands on company personnel to effectively manage a small workforce in busy and quiet shipping periods (Parker et al., Report No 2, 1998). These situations can contribute to work overload or underload conditions depending on the effectiveness of work allocation procedures.

11.2 Work Assignment Characteristics

The general work characteristics derived from the logbook data were consistent with the basic descriptions of work assignments obtained from the work schedule analysis (Parker et al., Report No 2, 1998). This was particularly evident in terms of the duration of travel to and from ships, the greater amount of travel on GNE Channel assignments, the significantly longer Inner Route assignments, and the irregularity of starting times of work and breaks across all three shipping routes.

The duration of work assignments varied from 54 hours on the Inner route to 16 and 14 hours on Hydrographers Passage and the GNE Channel, respectively. Ninety-five percent of this time was spent on pilotage duties while operating on the Inner route and GNE Channel in contrast to 67 percent on Hydrographers Passage.

The irregularity of Great Barrier Reef pilotage was consistent with work patterns in other pilotage groups (Shipley & Cook, 1980; Berger, 1984; de Vries-Grierer, 1982; Sparks, 1992; States British Columbia Oil Spill Task Force, 1997). Although comparisons with other pilotage groups enabled the general characteristics of work patterns to be evaluated, direct comparisons are limited due to the unique geographical and operational features encountered by the various pilotage organisations. For instance, the physical size of the Great Barrier Reef pilotage region requires extended work assignments which averaged 54 hours on the Inner Route. In contrast, pilotage assignments undertaken by UK pilots (Shipley, 1978) were relatively shorter and were classified as short haul (2.5 hours or less) or long haul (more than 2.5 hours).

The retrospective analysis of work schedules indicated that travel significantly increased the duration of work assignments and the amount of night work, and reduced the duration of breaks (Parker et al., Report No 2, 1998). Notably, travel to and from the ship was the highest rated of all the factors contributing to stress and/or fatigue on the three shipping routes. The logbook findings confirmed these results and provided additional evidence for the inclusion of work-related travel in the present work schedule system for the monitoring of fatigue.

11.3 Duration and Timing of Bridgework

It was clear from the logbooks that the characteristics of bridgework differed significantly across the three shipping routes. On the shorter routes, pilots spent 85 to 90 percent of pilotage time of 8-9 hours on the bridge in a single period, whereas on the longer route, 51 percent of the 49 hours of pilotage time was undertaken during multiple bridge periods averaging 3 hours. By comparison, UK pilots involved in long haul pilotage undertook 5.5 hours of bridge periods (Shipley, 1978), while a typical assignment performed by Port Phillip pilots involved 10 hours of navigation (Berger, 1984). Given that, on a tour of duty, the majority of Reef pilots alternate between the three routes, stable patterns of bridgework are not experienced. In this aspect, pilotage work differs considerably from conventional maritime watchkeeping systems with set hours on and off duty and with some limited disruption which may occur during port calls.

In the case of the GBR pilots, both long and short duration bridge periods may be factors in accident risk. Research results have shown that the relative risk of accidents increases as the number of hours on shift increases with a peak after a 13 hour shift (Folkard, 1995). However, the same author has also demonstrated that relative accident risk after 2-3 hours is as great as a 10 hour shift, that is a shorter duration shift may be riskier than a longer period. One explanation for this may be related to the time-dependent increase in mental lapses that are not compensated early in the shift by fatigue reducing strategies, such as physical movement or caffeine consumption (Sanquist et al., 1996). The present data revealed that during bridge periods alertness dropped marginally at the three-hour point, which coincided with the end of a short bridge period, and the middle of a longer bridge period. This finding tends to support the notion put forward by Folkard (1995) of an increased relative accident risk after 3 hours due to a drop in alertness at this point.

The effects on fatigue of irregular working hours appears to be markedly exacerbated when a proportion of this work occurs during night hours. In the case of GBR pilots, between 37 and 50 percent of bridge periods occurred during night hours which were defined as between 1818-0525 hrs. Approximately 30 percent of bridge periods were undertaken during the critical hours (defined as 2300-0600hrs), a period which has been shown to coincide with reduced alertness, sub-optimal performance and higher levels of fatigue (Costa, 1993; Meijman et al., 1993; Totterdell et al., 1995; Akerstedt, 1995; Luna et al., 1997). Questionnaire responses indicted that a considerable number of pilots reported feeling vulnerable to performance decrements during early morning hours (Parker et al., Report No 4, 1998). Additionally, a greater risk of accidents is associated with night work, especially in the early morning hours (Brown, 1994; Folkard, 1997; Mittler et al., 1988). This relationship is demonstrated by the higher frequency of shipping incidents during these hours in the Great Barrier Reef (Filor, 1998) and other navigational regions and transport industries (Sanquist et al., 1996; McCallum et al., 1996).

11.4 Alertness Ratings

On average, pilots rated their level of alertness at between 6 and 7 which is positioned towards the upper end of the rating scale. This level of alertness was comparable with ratings of mariners involved in day shift duties (Sanquist et al., 1996). Pilots also indicated that up to12 percent of bridge periods were associated with alertness levels consistent with sleepiness, and up to 58 percent of time on the bridge was associated with fatigue symptoms. These findings were inconsistent with the relatively high alertness ratings, and suggest that the pilots' estimates of alertness may have been slightly over rated. By comparison, an investigation of merchant marine personnel indicated 11percent of work periods were associated with minimum alertness and 28 percent of work periods displayed one or more fatigue symptoms (Sanquist et al.,1996).

The significance of maintaining optimal alertness levels during GBR pilotage is reinforced by reference to vessel accident /incident statistics in this region between 1985 and 1997. Of the 35 reported incidents, all areas of the reef in which GBR pilots operate were represented. This emphasises the high prevalence of potential hazards such as extensive reef networks, shoal water zones, narrow channels and variable tidal conditions throughout the pilotage region (AMSA, 1993; AMSA, 1996). This situation supports the need to sustain optimal alertness levels during bridgework throughout the whole pilotage region.

Several characteristics of bridgework, in particular, the duration, the percentage of bridge periods at night and during critical hours, low alertness levels, and the presence of fatigue symptoms, indicated likely reductions in work performance and thus increased accident risk. There was evidence to suggest that these factors are likely to be more problematic on Inner Route pilotages and with personnel who undertake a greater number of work assignments and experience shorter breaks than shown by average company figures (Parker et al., Report No 2, 1998).

11.5 Sleep Patterns at Sea

Many authors have reported reduced quantity and quality of sleep and a greater incidence of sleep disorders among individuals involved in work outside normal working hours (Berger, 1983; Griffiths, 1993; Harma, 1993; Parkes, 1994). This can be attributed to the fact that sleep taken during the daytime opposes circadian rhythms (Griffith, 1993; Rutenfranz et al., 1988; Scott & Ladou, 1990) and is often disrupted by social and environmental factors, such as activity, noise and heat. As a consequence, there tends to be an accumulative sleep deficit and increased levels of fatigue when successive night shifts are performed (Griffiths, 1993; Parkes,1994; Scott & Ladou, 1990).The disrupted or inadequate sleep experienced by shiftworkers may have ramifications with respect to work performance and tasks with a high vigilance component are particularly sensitive to sleep loss. Performance deterioration as a function of sleep loss tends to be further exacerbated when a cumulative sleep debt is incurred and as a consequence safety may be seriously compromised (Tilley et al., 1982).

Logbook data provided the first opportunity to record additional details with respect to the patterns and quality of pilots' sleep while at sea and ashore. Sleep patterns at sea differed according to: the particular shipping route; the duration of sleep at sea; the duration of each sleep period; and the number of sleep periods. For example, logbook analysis revealed total sleep time per 24 hours ranged from 0.6 hours for the GNE Channel to 4 and 5.25 hours for Hydrographers Passage and the Inner Route, respectively. Sleep was also fragmented, particularly on the Inner Route, with an average of three sleep periods taken during each 24 hours. By comparison with other maritime studies the sleep duration of the present pilot group was shorter, with an average of 6.6 and 7.5 hours daily being reported for US and European mariners, respectively (Sanquist et al.,1996; Rutenfranz and others (1988). These group differences are likely related to the shorter periods of time pilots spend onboard vessels and the on call nature of pilotage work. The fatiguing effects of the relatively short and fragmented sleep at sea, may be further exacerbated by the finding that up to 50 percent of this sleep is outside optimal hours (2200-0800) on the Inner Route and GNE Channel and thus may be inferior in terms of its recuperative value.

Other findings indicative of a fatigued state were demonstrated by the fact that approximately 40 percent of sleep periods at sea and ashore displayed latencies of less than 5 minutes, and almost all of the time in bed was spent with little loss of sleep due to awakenings.

Another aspect of sleep which has the potential to impact on fatigue and performance is the daily sleep debt which is defined as the difference between the hours of sleep ashore and at sea. The daily sleep debt of 3 hours incurred by pilots is greater than that found in other Australian seafarers (Parker et al, unpublished data) and US merchant marine personnel (Sanquist et al., 1996). However, when assessing the impact of the sleep debt, it should be noted that pilots return ashore during assignment breaks following work at sea lasting between 14-16 hours on the shorter routes and 54 hours on the longer route. In contrast, other seafarers in Australian and international fleets tend to stay at sea for up to 8 weeks and thus may incur the sleep debt for markedly longer periods.

Nevertheless, previous study results have indicated that even a reduction in sleep of 1.5-2 hours for one night is associated with decreased human performance (Gillberg, 1995). Such sleep deprivation may be characterised by a slower response speed to new and previously encountered stimuli (Dinges,1992; McCarthy & Waters, 1997), an increased tendency for false positive responding (Dinges, 1992), memory problems and slowed responses to unexpected events (Dinges & Kribbs, 1991). From questionnaire responses during the present project, pilots considered that performance decrements manifested as difficulty in concentrating, maintaining attention and memory problems (Parker et al., Report No 4, 1998). Such performance decrements could potentially have serious implications on piloting performance and may jeopardise ship safety.

While the acute sleep debt incurred during one assignment may be partially eliminated by the recuperative sleep ashore during breaks, there is the potential for chronic sleep debt to occur when breaks ashore do not provide sufficient recuperative sleep. In terms of vigilance levels and safe navigation, several studies have shown that chronic sleep deprivation reduces the ability to direct attention to the task at hand (Blagrove, et al., 1995; Herscovitch & Broughton, 1981). In the present pilot group sleep deprivation could be best described as intermittent, however, the consequences of chronic sleep deprivation may still be experienced at a relative level.

Pilots themselves acknowledged the difficulties associated with sleep at sea. Pilot commentaries indicated that opportunities for sleep at sea during Great Barrier Reef pilotage work varied greatly and were dependent on the shipping route, the ships schedule, prevailing conditions and bridge team competency.

Several suggestions from pilots for improving sleep opportunities at sea related to the charting of additional regions to bypass difficult navigational sections of shipping routes and the extension of navigational aids throughout the entire region (Parker et al., Report No 4, 1998).

11.6 Breaks between Assignments

In most situations, fatigue can be alleviated by an adequate period of rest between work assignments. However, if the rest period is insufficient to allow effective recuperation and alertness, fatigue will accumulate and manifest in a chronic form (Cameron, 1974, Grandjean, 1970). Schedules that employ limited rest time tend to result in cumulative fatigue as the rest period cannot completely offset the fatigue acquired during the work. While the adaptive nature of humans may enable performance to be maintained at a satisfactory level for some time, during periods of increased stress individuals who persist with these schedules are usually unable to cope and performance decrements become evident.

The impact of shipping route duration on work and sleep at sea is addressed in a basic way by the present guidelines for minimum rest breaks between consecutive pilotage assignments performed in the Great Barrier Reef-Torres Strait region. These guidelines state that prior to any work assignment, a minimum of 12 consecutive hours of rest, excluding travel must be taken by the pilot, except when the Inner Route passage is to be piloted, in which case at least 24 consecutive hours of rest, excluding travel is required (AMSA, 1997).

Closer examination of activity during assignment breaks indicated breaks averaged between 35 and 72 hours. While average break figures appeared to indicate that break duration was in keeping with guidelines for rest breaks some concerns were identified. Our extensive analysis of 4310 work assignments (Parker et al., Report No 2, 1998) and confirmed by logbook data, showed that between 5 and 10 percent of breaks did not conform to present guidelines for rest breaks. In addition, breaks between assignments began at all hours during the 24 hour cycle, thus displacing a proportion of sleep from the normal circadian cycle.

11.7 Sleep Ashore

Sleep ashore averaged from 9 to 11 hours per 24 hours, and was taken in one sleep period of approximately 7 hours with an additional shorter sleep of 2-3 hours. Pilots reported that they were able to sleep with relative ease considering the timing irregularities and the frequent change of location (Parker et al., Report No 4, 1998). However, it is unlikely that pilots have undergone any adaptation to irregular work and sleep patterns despite the many years of pilotage service. Within the literature there is considerable evidence which indicates there is little, if any, circadian adaptation to work schedules involving frequent changes of work times (Colquhoun 1985; Costa 1993; Luna 1997; Monk & Folkard 1992). In terms of the timing of sleep ashore, between 20 and 30 percent of sleep was taken outside the optimal sleep hours of 2200-0800 hours and considerable evidence exists to indicate that such sleep has diminished recuperative value (Akerstedt, 1995; Folkard, 1996; Tilley et al., 1982; Folkard & Barton, 1993; Kecklund et al., 1997). Logbook data also revealed that 60 percent of assignment breaks were spent either in pilot accommodation, hotels/motels. Therefore, exogenous factors such as poor sleeping facilities, outside noise and activity, increasing temperatures and natural sunlight may further compromise sleep when taken out of regular sleeping hours (Akerstedt, 1995; Rutenfranz et al., 1988).

Recovery values of sleep following a period of normal wakefulness have been estimated as a function of different lengths of sleep. For instance, 8 hours of sleep provides 100 percent recovery, whereas 2.8 hours of sleep gives only 67 percent recovery. However, he also indicated that these values may exaggerate the exponential nature of recovery, that is, recovery may be more linear (Simon Folkard, Personal Communication, June, 1998).

A significant proportion of the evidence related to breaks and sleep at sea and ashore suggested that sleep was likely to be of poor quality. Therefore, the finding that pilots reported relatively high sleep quality at sea and ashore was slightly unexpected and inconsistent with previous reports on this group which indicated that the majority of pilots experienced poor to very poor sleep quality at sea (Parker et al., 1997). By comparison, pilots sleep quality ratings were in the range reported by merchant marines involved in daywork, and higher than those reported by watchkeepers (Sanquist et al.,1996). Thus the present group may have slightly overrated sleep quality which is not unusual in studies involving subject assessments, particularly in occupational settings.

11.8 Relationship between work and sleep patterns and fatigue

A major aim of the logbook analysis was to identify key factors associated with the work and rest patterns that are correlated with fatigue and decreased alertness on the bridge. To this end a number of statistical models were constructed as an initial step towards the development of a formula to predict fatigue, stress and alertness on the bridge.

The results of the modelling process indicated that pilot differences in stress, fatigue and alertness, work assignment and break duration accounted for over 90 percent of the variance in fatigue, stress and alertness levels during bridge work. It was notable that break duration prior to assignments accounted for relatively more of the variance in alertness than in fatigue or stress. In contrast, the duration of the assignment accounted for relatively more of the variance in stress and fatigue than in alertness. That a considerable proportion of work assignment and pilotage time is spent on the bridge in the Barrier Reef region suggests that the increased fatigue is a result of not only the long hours but also exposure to other workplace stressors during these prolonged periods of work (Spurgeon et al.,1997).

The substantial variance in fatigue, stress and alertness attributed to by individual pilot differences may reflect actual differences in pilots' thresholds to cope with these three factors. Alternatively this finding may simply be due to limitations in the use of rating scales to make comparisons across groups or to the 'negative effect' phenomenon identified in the literature, that is, some individuals complain about everything – others complain about nothing. While a cautionary approach should be taken to the significance of individual pilot differences, there is evidence in the literature to suggest the existence of several factors which may influence individual thresholds in coping with stress and fatigue. For example, basic differences in physiological measures of health and fitness and personality differences could be expected to influence tolerance to various aspects of pilotage work. Poor levels of physical fitness have been shown to reduce an individual's ability to handle the stress associated with irregular hours (Harma, 1993).

During an investigation of UK pilots it was noted that individuals who found it difficult to relax, and whose biological systems did not tolerate work outside normal hours, could be considered 'vulnerable' and hence display a lower threshold for coping with the highly variable work situations (Shipley, 1978). It is also generally recognised that increasing age has adverse effects on tolerance to shiftwork as it brings about changes not only in the sleep/awake cycle but also tends to result in earlier phasing of circadian functions, that is, people become more 'morning oriented' as they age (Gander et al., 1993, Harma, 1993, Parkes, 1994). Interestingly, the present pilots who had an average age of 53 years considered themselves more morning than evening oriented (Parker et al., Report No 4, 1998).

The modelling procedures identified a number of key items which are currently included or could be included in the reporting procedures to enhance the value of the data with respect to the prediction of fatigue in pilots These items comprise, work assignment and break duration data, total duration of bridge periods, time on the bridge during critical hours, (that is, between 2300-0600 hrs) and travel data. These models could be further refined to include more detailed temporal aspects of work and sleep patterns which would enable changes in fatigue, stress and alertness during bridgework to be predicted for each additional hour of duty on the bridge.

Although preliminary, the current modelling is consistent with and complementary to previous approaches to exploratory modelling of alertness and fatigue in other maritime studies. For instance, Sanquist et al. (1996) reported that total sleep quality was the main predictor of alertness during a work period. On the other hand, modelling based on the outcomes of casualty investigations, found sleep and work duration in the past 72 hours and reports of fatigue symptoms correctly classified 80 percent of casualty cases in terms of the presence of fatigue (McCallum et al., 1996). Another model, which was developed to evaluate the impact of reduced sleep on alertness (Akerstedt & Folkard, 1995) could be extremely useful in the maritime setting with further refinement to include the restorative value of sleep across the 24 hour cycle and the impact of major restricted sleep periods (Sanquist et al., 1996).

11.9 Other factors contributing to fatigue

A common theme throughout the various phases of this research was the perception by pilots and their wives/partners that the introduction of competition had a negative impact on financial security, safety and domestic situations (Parker et al., Reports No 3 & 4, 1998). It is acknowledged by pilots that many aspects of pilotage such as the irregularity of work and breaks, the percentage of work at night and during critical hours are present whether or not a single, or multi provider situation prevails. However, there is evidence from comments by pilots and their partners that commercial interests and the desire to maintain income levels results in the need to undertake increased numbers of assignments and a reduction in break periods. As evidenced earlier in this report these increased loads are likely to compound the potential to develop fatigue. Although there is very limited information related to the impact of competition on fatigue in mariners there is a strong feeling among pilots in Australia and overseas that competition may compromise safety, particularly when pilots are expected to exercise independent judgment and resist pressures which are inconsistent with the interests of safety (Sparks,1998, Cash, 1998).

In summary, the various phases of this project represent the first comprehensive examination of the work practices of GBR pilots and the likely impact of these practices on the development of fatigue. The project was initiated following an earlier survey of the Health, Stress and Fatigue of Australian Seafarers which identified a number of concerns regarding fatigue in this population. These included the reduced quantity and quality of sleep while at sea, and an older workforce with some evidence of increased cardiovascular risk factors. The potential for a major environmental catastrophe in the Great Barrier Reef region and the increasing recognition of the importance of human factors and fatigue in both vessel and personnel accidents also provided an important stimulus for the implementation of this research. The research was also conducted against a background of significant change in the maritime industry and introduction of competitiveness and increased commercial pressures in shipping generally, and pilotage in particular.

The results from all phases of the research have shown that the work practices of pilots are characterised by several features relating to both work assignments and bridge and sleep periods at sea and sleep ashore that have the potential to increase fatigue levels. These include the irregularity of work and displaced work and sleep from normal circadian cycles, a considerable percentage of bridge work during night and early morning hours, short and fragmented sleep at sea with a considerable percentage of sleep at sea and ashore taken in opposition to normal physiological sleeping times for optimal recuperative value. Furthermore, the fluctuations in workloads during particular time periods and the situations where personnel undertook considerably greater workloads and shorter breaks than average company figures further exacerbated the fatigue potential related to the general and specific features of pilotage work.

The research has provided extensive documentation of the work practices of GBR pilots and some evaluation of the nature and extent of fatigue associated with these practices. The findings provide a basis for the establishment of enhanced fatigue monitoring and management procedures and their implementation at a regulatory, company and individual level.

References

Appendix 1

LIST OF TABLES

Appendix 2

LIST OF FIGURES

- Figure 9.2: Mean number of fatigue symptoms experienced during bridge periods, by shipping route
- Figure 9.3: Mean percent of bridge periods associated with one or more symptoms of fatigue, by shipping route

APPENDIX 5

ENHANCED DATA COLLECTION BASED ON PRELIMINARY RESULTS OF STATISTICAL MODELLING

COMPLETE A SEPARATE SHEET FOR EACH ASSIGNMENT

WORK ASSIGNMENT NO………… DATE……….

TRAVEL TIME TO BOARDING GROUND (hrs)……….

TRAVEL TIME FROM BOARDING GROUND (hrs)………

BRIDGE PERIOD	**Start time 24 hour**	**Finish time 24 hour**	**Duration of bridge period (hrs)**	**Duration of bridge period (hrs) between 2300-0600**
No 1				
No 2				
No 3				
No 4				
No 5				
No 6				
No 7				
No 8				
No 9				
No 10				
No 12				
No 13				
No 14				
No 15				
No 16				
No 17				
No 18				
No 19				
No 20				
Total duration of bridge periods per assignment				
Total duration of bridge periods between 2300-0600				

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APPENDIX 4

PERSONAL FATIGUE CHECK LIST

The personal fatigue checklist is an example of a simple approach to increasing an individual pilots awareness of a potential fatigue situation. The items included reflect some of the key areas identified in the research as being conducive to fatigue.

PERSONAL FATIGUE CHECK LIST

ITEMS	**Mostly**	**Some times**	**Never**	**ITEMS**	**Mostly**	**Some times**	**Never**
WORK				**BREAKS**			
How often do you undertake an excessive number of work assignments during a tour?				How often is your break reduced due to increased workloads?			
How often is bridgework at night?				How often is your sleep less than a continuous 8-9 hours while ashore?			
How often have your assignments been on the Inner Route recently?				How often is your sleep outside optimal hours (2200-0800) while ashore?			
How often do you have very little sleep at sea?				How often do you still feel tired and exhausted after your break ashore?			
How often do you go to sea with other problems on your mind?				**LIFESTYLE** Do you feel unable to relax at home and enjoy family life between tours? Do you feel unable to take a holiday free of pilotage duties?			
How often do you fall asleep at sea or ashore in < 5 minutes?							
FATIGUE SYMPTOMS How often do you experience the following? Forgetful Difficulty staying awake Distracted Less motivated Sore muscles Sore eyes				**FATIGUE CONSEQUENCES** How often do you experience difficulty with? Erroneous actions Erroneous decisions Slow reactions Improper procedures			

1. MOSTLY = RED ZONE = HIGH FATIGUE RISK 2. SOMETIMES = ORANGE ZONE = MODERATE FATIGUE RISK 3.NEVER = GREEN ZONE = LOW FATIGUE RISK

If the majority of your responses are in the RED ZONE your fatigue risk is high

If the majority of your responses are in the ORANGE ZONE your fatigue risk is moderate.

If the majority of your responses are in GREEN ZONE your fatigue risk is low.

YOUR AIM SHOULD BE TO MOVE YOUR RESPONSES FROM THE RED ZONE

APPENDIX 3

LOGBOOK

GREAT BARRIER REEF PILOTS

YOUR PERSONAL CODE ....

WORK ASSIGNMENT No ....

Shipping route (please tick)
1 ☐ GNE CHANNEL 2 ☐ INNER ROUTE
3 ☐ HYDROGRAPHERS PASSAGE 4 ☐ OTHER

DATE, TIME AND LOCATION OF EMBARKATION:

DATE... DD/MM/YY

TIME.. 24 HOUR

LOCATION...

TRAVEL TIME TO BOARDING GROUND.................. HRS

DATE AND TIME PILOT DUTIES COMMENCED:

DATE... DD/MM/YY

TIME.. 24 HOUR

DATE AND TIME PILOT DUTIES CEASED:

DATE.. DD/MM/YY

TIME... 24 HOUR

DATE, TIME AND LOCATION OF DISEMBARKATION:

DATE.. DD/MM/YY

TIME... 24 HOUR

LOCATION..

TRAVEL TIME FROM BOARDING GROUND...............HRS

WORK PERIOD ON BRIDGE No.........

Sea conditions PLEASE TICK
1 ☐ Calm (0-1.5 m) 2 ☐ Medium (1.5-5.4m) 3 ☐ Heavy (5.4-13.7m)

For each of the following stages of the work period, put a **VERTICAL MARK** on the line to indicate how you feel

<u>Beginning of Work Period</u>: Date____________ Time____________
DD/MM/YY 24 HOUR

Very sleepy Very alert

<u>Middle of Work Period</u>: Date____________ Time______________
DD/MM/YY 24 HOUR

Very sleepy Very alert

<u>End of Work Period</u>: Date____________ Time____________
DD/MM/YY 24 HOUR

Very sleepy Very alert

Did you experience any of the following during this work period. **CIRCLE ONE NUMBER FOR ITEMS EXPERIENCED**

	Not at all		A little		Quite a bit		Very much
Forgetfulness	1	2	3	4	5	6	7
Distracted	1	2	3	4	5	6	7
Attention difficulties	1	2	3	4	5	6	7
Decreased motivation	1	2	3	4	5	6	7
Did things at wrong time	1	2	3	4	5	6	7
Sore muscles	1	2	3	4	5	6	7
Heavy eyelids	1	2	3	4	5	6	7
Desire to sit or lay down	1	2	3	4	5	6	7
Itchy eyes	1	2	3	4	5	6	7
Difficulty focusing eyes	1	2	3	4	5	6	7

SLEEP AND NAP PERIOD AT SEA No ....

Please complete the following whenever you sleep or take a nap while working on a ship at sea

Sea conditions PLEASE TICK
1 ☐ Calm (0-1.5 m) 2 ☐ Medium (1.5-5.4m) 3 ☐ Heavy (5.4-13.7m)

Date ________________ **Time** _________________
DD/MM/YY 24 HOUR

I went to bed at ____________________ (24 Hour)

I started trying to go to sleep at ________________(24 Hour)

It took me ___________ minutes to fall asleep

I woke up ___________ times during the sleep period

I lost _____________ minutes of sleep

I finally awoke at ________________ (24 Hour)

I got up at ________________ (24 Hour)

Rate Your Sleep

For all questions, 1 indicates worst sleep conditions, while 5 indicates your best sleep conditions. For example, if it was most easy to fall asleep circle 5. Alternatively, if you felt the least rested after the sleep period, circle 1 for the last question

	Least (1)		Most (5)		
Ease of falling asleep	**1**	**2**	**3**	**4**	**5**
Ease of arising	1	2	3	4	5
Was this sleep period sufficient?	1	2	3	4	5
How rested do you feel?	1	2	3	4	5
Depth of sleep	1	2	3	4	5

.

END OF WORK ASSIGNMENT ASSESSMENT

____

Date: (DD/MM/YY)

Please rate the following for this work assignment by placing a **VERTICAL MARK** on the line.

Overall Stress

Very Low   Very high

____

Overall Fatigue

Very Low   Very high

____

To what degree did the following factors increase your overall levels of stress and/or fatigue?

Bridge Team

Not at all   Very much

____

Ship Length: length = ...(metres)

Not at all   Very much

____

Average Ship speed: ship speed = ...(knots)

Not at all   Very much

____

Cargo Type

Not at all   Very much

____

Equipment availability

Not at all   Very much

____

Ship Handling Capabilities

Not at all   Very much

____

END OF WORK ASSIGNMENT ASSESSMENT (cont)

Under keel clearance: draft = ...(metres)

Not at all Very much

Weather

Not at all Very much

Visibility

Not at all Very much

Shipping traffic

Not at all Very much

Recreation traffic

Not at all Very much

Language/communication difficulties

Not at all Very much

Meals

Not at all Very much

Accommodation

Not at all Very much

Travel to Boarding Ground

Not at all Very much

Travel from Boarding Ground

Not at all Very much

ADDITIONAL COMMENTS ABOUT THE WORK ASSIGNMENT

ASHORE PERIOD

SLEEP AND NAP PERIOD ASHORE

Please complete the following whenever you sleep or take a nap during the **first 72 hours** spent ashore after a work assignment

Location of Accommodation Ashore PLEASE TICK

1. ☐ At home
2. ☐ Pilot Accommodation
3. ☐ Motel/Hotel
4. ☐ Other

Date________________ DD/MM/YY

Time_________________ 24 HOUR

I went to bed at ____________________ (24 Hour)

I started trying to go to sleep at ________________(24 Hour)

It took me ___________ minutes to fall asleep

I woke up ___________ times during the sleep period

I lost _____________ minutes of sleep

I finally awoke at ________________ (24 Hour)

I got up at ________________ (24 Hour)

Rate Your Sleep

For all questions, 1 indicates worst sleep conditions, while 5 indicates your best sleep conditions. For example, if it was most easy to fall asleep circle 5. Alternatively, if you felt the least rested after the sleep period, circle 1 for the last question.

Least (1) Most (5)

Ease of falling asleep	**1**	**2**	**3**	**4**	**5**
Ease of arising	1	2	3	4	5
Was this sleep period sufficient?	1	2	3	4	5
How rested do you feel?	1	2	3	4	5
Depth of sleep	1	2	3	4	5