An analysis of the work schedules of Great Barrier Reef pilots

Acknowledgements

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Summary of results

The analysis of the work schedules, which included 902 tours of duty and 4310 work assignments, provided a basic description of the work practices of Great Barrier Reef pilots based on ship and non-ship periods. Key measures analysed from the work schedule files included the characteristics of tours of duty, work assignments, shipping routes and work-related travel. The analysis of the files was retrospective in nature and covered the 18 month period from January 1, 1996 to June 30, 1997. Between company differences and changes across three 6 month periods were assessed. Unless otherwise stated all measures were based on 6 month periods.

The differences in operations between the three pilotage companies are reflected in the results of the analyses. Company C is a small, newly established company operating in a

single pilotage region only; Companies A and B are larger, longer established companies operating on all three shipping routes in the region.

Characteristics of tours

During a tour of duty, pilots perform one or more work assignments and alternate between working at sea and living ashore. The number and duration of tours, duration of breaks between tours and percent of tour time spent on assignment may, singly or in combination have some effect on the fatigue status of marine pilots. Analysis of the tour characteristics revealed that:

- Company C performed significantly shorter tours, had seemingly longer rest breaks and spent a greater percentage of tour time on work assignments, than either Companies A or B. These results reflect the small size and single operational region of Company C.
- Company B personnel performed more tours than Company A.
- Breaks between tours were on average approximately 20 days for Company A and 13 days for Company B.
- Mean tour duration was approximately 18 days for Companies A and B and 3 days for Company C.
- Percent of tour time spent on work assignments ranged from approximately 50% for Companies A and B to 70% for Company C.
- Frequency distributions indicated that in both Companies A and B, there was a small group of pilots performing more tours, longer tours and experiencing shorter breaks between tours, than depicted by mean company figures.
- Analysis across the three 6 month time periods revealed that the duration of tours increased during the second time period.

Characteristics of work assignments

Work assignments involve a continuous period of time spent by pilots on board vessels. Each work assignment was clearly identifiable in work schedule files by date, time and location of embarkation and disembarkation points. As travel to and from ships was regarded as work, assignment duration was travel adjusted. Between work assignments pilots live ashore. Analysis of work assignment characteristics showed that:

Number of work assignments

- Company B personnel performed significantly more work assignments per tour than pilots from either of the other companies.
- The average number of work assignments performed by pilots from Companies A, B and C were 22, 29 and 7 respectively. These findings reflect a 31% greater workload for pilots from Company B compared with Company A.
- Company B pilots performed approximately 51% more work than Company A pilots on the Inner Route.
- Significantly fewer work assignments were performed by Company A personnel on Hydrographers Passage compared with the other two companies.
- A similar number of work assignments were performed by Companies A and B on the Great North East Channel.

- Frequency distributions for work assignment per tour and per pilot indicated that in some instances, substantially more work assignments were undertaken. Compared with average company figures, there were some situations when almost twice as many work assignments were performed. This distribution pattern also applied when the number of assignments performed on the Inner Route and Hydrographers Passage were assessed.
- A significantly greater number of work assignments per tour, per pilot and on the Inner Route were undertaken during the second 6 month period. This temporal pattern was observed for all of the pilotage companies, thereby indicating an increase in overall work availability during this period.

Duration of work assignments

- Average work assignment duration for Companies A, B and C was approximately 46, 41 and 14 hours respectively.
- Frequency distributions showed that in both Companies A and B, there were a number of assignments which greatly exceeded average work assignment duration.
- Compared with other groups of marine pilots, the duration of work assignments performed by Great Barrier Reef pilots were substantially longer.

Duration of rest breaks between work assignments

- Company A pilots experienced longer breaks between work assignments compared with Company B.
- Distribution curves for all companies were markedly skewed, thereby indicating that most consecutive work assignments were interspersed by 24 hours or more. However, there were a number of situations for Companies A and B when break duration was less than current minimum rest break regulations. This applied to all three shipping routes.
- By calculating work to rest ratios for Great Barrier Reef pilots and long haul pilots from the United Kingdom, it was evident that rest periods relative to work periods were substantially shorter for Great Barrier Reef pilots.

Duration of work assignment at night

- Average duration of work assignments performed during the night for Companies A, B and C was approximately 25, 23 and 7 hours respectively. These figures represent approximately 50% of total assignment time for each of the companies.
- The distribution curves displaying the percent of assignment time at night show that the majority of work assignments for Companies A and B involve between 40 - 60% of night work. That some work assignments performed by Company C involved almost total night work reflects the short transit time through Hydrographers Passage.
- The amount of work performed at night did not vary significantly over time thereby suggesting regular night work is a common feature of Great Barrier Reef marine pilotage.

Starting times of work assignments and breaks

- Starting times of Great Barrier Reef pilotage work assignments were fairly evenly distributed across the six 4 hour period making up the 24 hour cycle. This pattern was consistent for all companies and across time.
- Starting times of breaks between work assignments also showed an even distribution across the six 4 hour period making up the 24 hour cycle. It would therefore appear that a high level of irregularity in the timing of work and rest breaks is present in Great Barrier Reef

marine pilotage work. This finding is consistent with the available literature on other groups of marine pilots.
- These findings suggest that work and sleep would frequently be asynchronous with normal circadian rhythms of the body.

Opportunity for optimal sleep during assignment breaks

- Breaks between assignments for Company B provided fewer opportunities for uninterrupted sleep during optimal circadian periods (2200-0800 hours) than Company A's breaks.
- There were a number of occasions over the 18 month analysis period for all three companies when rest breaks between assignments failed to present pilots with any opportunity to achieve uninterrupted sleep during optimal periods.

Characteristics of shipping routes

The three main shipping routes transited by Great Barrier Reef pilots include Hydrographers Passage, the Inner Route and the Great North East Channel. Both Hydrographers and the Inner Route are areas of compulsory pilotage. When an analysis of the shipping routes was undertaken, it was identified that:

- Inner Route assignments constitute ~ 70% of Great Barrier Reef pilotage work, Hydrographers Passage assignments, ~ 20% and Great North East Channel assignments, ~ 10%.
- Inner Route assignments were significantly longer than assignments on either of the other two shipping routes.
- Average transit time through Hydrographers Passage was shortest.
- A higher percentage of night work was experienced on the Inner Route.
- Starting times of assignments and breaks on the three routes were fairly evenly distributed across the 24 hour cycle.
- Significantly more travel to and from ships was undertaken on the Great North East Channel.
- The opportunity for uninterrupted sleep during optimal periods (2200-0800 hours) was significantly less during rest breaks prior to assignments on Hydrographers Passage.

Characteristics of travel

Great Barrier Reef pilots undertake a substantial amount of work-related travel. Given that travel may potentially impact on recovery periods and hence, influence the fatigue status of pilots, an assessment of the impact of travel was conducted.

The States/British Columbia Oil Spill Task Force has stated that travel to and from work and between work should be considered part of work hours (States/British Columbia Oil Spill Task Force, 1997). In consultation with Great Barrier Reef pilot advisory group members, it was decided that travel to and from embarkation and disembarkation grounds and travel between work assignments should constitute work. Accordingly, travel data was input into existing work schedules. No distinction between the mode of travel used (launch, helicopter, fixed wing aircraft) was made; only travel time was considered.

- Travel significantly increased work assignment duration, decreased breaks between work assignments and increased the night time periods during work assignments.

- Travel from all sources per tour for Companies A, B and C was approximately 12, 18 and 4 hours respectively. These figures represent significantly longer hours of travel for pilots from Company B.
- The analyses of travel time to and from ships and between ports indicate that Company B personnel engage in more travel per tour than Company A.
- Company C undertakes no travel between ports, given their single operational region.
- Company B pilots incurred more travel to and from ships per work assignment.
- On average, less than 10% of break times between ships were spent travelling; however, travel is most likely fragmented throughout the assignment break period, thereby reducing the recuperative value of recovery periods.
- Over the 18 months, significantly more travel was undertaken during the second 6 month period. This result is consistent with previous findings indicating increased work availability during this period.

Summary

A number of potential key indicators of fatigue were identified from the analysis of the work schedule files. For example, the irregularity of work assignments (ship time) and rest breaks (non-ship time), the substantial percentage of ship time undertaken at night, and the displacement of work and sleep from normal circadian cycles could, singly or in combination, impact on the fatigue status of pilots. It was also identified that work-related travel significantly increased work assignment duration, decreased the duration of breaks between assignments and increased the percentage of night work. Additionally, there was a distinct increase in work availability in all pilotage groups in the second time period (June-December, 1996). Hence, travel and work availability may exacerbate the effects of other potential fatigue factors.

To some degree the increased commercial pressures created by the privatisation of pilotage in the Great Barrier Reef region is reflected in the between company differences in work assignment characteristics; over the 18 month analysis period, Company B personnel performed greater workloads than Company A pilots. It was also recognised that there were some instances when personnel from both Companies A and B performed considerably more assignments and experienced shorter breaks than average company figures. Although extreme workloads were undertaken by only a small group of pilots, it is these situations which are of concern in the context of both acute and chronic fatigue development, performance decrements and risk of accident.

Areas for consideration

The analyses of the work schedule files strongly suggest that there is a high potential for fatigue among Great Barrier Reef pilots. The extensive analyses based only on ship and non-ship time revealed the presence of several factors previously identified in the literature as impacting on fatigue. These were:

- irregular timing of work and rest periods across the 24 hour cycle;
- long on-ship periods;
- night work;
- 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 time period (July-December) increase in work availability; and
- significant company differences in workload levels.
- As indicated in previous communications analysis of the work schedule data provides only one source of information related to the fatigue aspects of the work of Great Barrier Reef pilots. The work schedule information is an extensive data set comprising 4310 records reported retrospectively to AMSA over an 18 month period. It was the only data available to the researchers but is a valuable resource, the analysis of which has provided some useful information which may be applied to the evaluation of the existing reporting and monitoring system and identification of areas worthy of consideration, and which may enhance current procedures.

At this stage the applicability of the results to any modification of scheduling guidelines is limited as the present reporting system provides no specific details regarding the nature of work and rest periods and their impact on fatigue and performance. Without this information it is difficult and irresponsible to suggest definitive strategies and changes to work scheduling practices. Satisfactory completion of the final stages of the project and the additional log book data should provide a more substantive basis for the recommendation of guidelines concerned with these work practices.

The findings from this phase of the project together with information from the research literature provide opportunities for AMSA together with the pilot advisory group and the research team to consider a number of broad areas which may lead to improvement in the present reporting and monitoring of work scheduling practices. To this end it is suggested that the results of this interim report be considered by AMSA and the Pilot Advisory Group with reference to the following areas:

- The adequacy of the current system of reporting work/rest information;
- The inclusion of additional information to enhance reporting and knowledge of potential fatigue indicators;
- The design of more efficient reporting systems to provide a more pro-active/preventative approach to potential fatigue problems rather than the more reactive system currently operating;
- The significance of travel time in the fatigue equation;
- The monitoring of work/rest guidelines;
- The development of a system which, (a) enables companies to allocate work to pilots which is consistent with the guidelines for rest breaks and (b) evens out the distribution of work and rest over the year and optimises the use of personnel during busy periods.

Section 1 - 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 Great Barrier Reef pilots. An important finding was the poor quality and 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 Great Barrier Reef 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 Queensland University of Technology, and involved the following phases:

- Phase I A review of the existing literature of the work practices of marine pilots
- Phase II Analysis of work schedule data across an 18 month period (1 Jan 1996 - 30 June 1997) to develop a description of ship and non-ship time.
- Phase III A background survey of pilots designed to provide a profile of this group and an overall description of sleep patterns, pilotage specific experience and alertness.
- Phase IV A background survey of wives/partners of marine pilots to identify the impact of pilotage work on home and family life and address psychosocial issues.
- Phase V 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 will be valuable in the development of strategies and guidelines to reduce the potential for fatigue and risk of accident.

This interim report represents Phase II of the project and contains analyses of retrospective work schedule data provided by AMSA. A Pilot Advisory Group, group comprising one member from each of the pilotage companies operating in the Great Barrier Reef – Torres Strait region was associated with all stages of the projects development. Regular meetings were held with the researchers and a representative from AMSA and there were frequent informal communications between members of the Advisory Group and the research team.

Section 2 - introduction

The Great Barrier Reef – Torres Strait region has been recognised both nationally and internationally as a unique and environmentally sensitive area. It has been 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 & AMSA 1996). Coastal pilotage in the region is centred on the movement of ships along and through the Great Barrier Reef, with pilotage times ranging from 10 hours to in excess of 60 hours. Pilotage is often conducted in trying conditions with pilots having to cope with varying ship, equipment and crew standards combined with the vagaries of weather and traffic. Additionally, ships may be carrying potentially hazardous and highly polluting cargo, and are often deep laden causing intricate navigational problems. Hence, it is possible that the characteristics of Great Barrier Reef pilotage may have the potential to impact on fatigue levels and work performance.

There are three pilotage companies operating in the Great Barrier Reef region. Each company allocates work based on a turn system designed to ensure equality between pilots in workload, rest breaks and income, and to match pilot abilities with expected work requirements. Work schedules involve tours of duty during which time pilots are on call and perform one or more work assignments. Time between work assignments is spent ashore recuperating, and if necessary travelling to the next port location. For pilots who live in close proximity to their work location, recovery time between assignments may be spent at home. However, a considerable number of Great Barrier Reef pilots live distant from their work and hence time between work assignments is spent in alternative accommodation (e.g., hotels, motels, pilot houses). Following a tour of duty an extended period of rest at home is usually taken.

Marine pilotage work is dependent on shipping demands and tidal conditions and as a consequence, work schedules are highly irregular. Work may be undertaken at any time of the day or night, as is evidenced by an investigation of United Kingdom pilots revealing that the entire 24 hour period was represented when the starting and finishing times of marine pilotage work patterns were analysed (Shipley & Cook, 1980). Night work is common, with preliminary findings from the present investigation indicating that 54 percent of ship time of Great Barrier Reef pilots is undertaken during the night (where night is defined as between 1818 and 0525 hours) (Parker et al. unpublished observations).

Work during unconventional hours opposes the normal diurnal nature of the human body, as individuals attempt to maintain high levels of alertness when their body is anticipating sleep, and try to sleep when alertness and arousal are naturally increasing. As a consequence, sleep quantity and quality are frequently compromised and circadian dissociation may be experienced. This, in turn, leads to increased levels of fatigue, mood deterioration and performance decrements (Akerstedt 1995; Condon et al. 1988; Krueger 1989; Monk 1989; Monk & Folkard 1992; Rosekind et al. 1996; Scott & Ladou 1990; TSB 1997). Specifically, performance on cognitive, vigilance and memory tasks may be adversely affected by fatigue (Griffiths 1993; Krueger 1989; TSB 1997). In terms of pilotage performance, this may result in lowered levels of vigilance, slowed reaction times, impaired decision making and judgment and adopting simpler, but riskier problem solving strategies (Couper 1996; Dinges 1992; Sanquist et al. 1996).

Additionally, it has been recognised that working during unconventional hours may be associated with a greater relative risk of accidents. Findings from primary studies (Hopkins 1992; Summala & Mikkola 1994) and a number of review articles (Brown 1994; Couper 1996; Folkard 1997; Mitler et al. 1988; Sanquist et al. 1996) indicate that accident risk is greatest during the early morning hours, particularly 0300 hours, with an additional but smaller peak in accident risk occurring in the mid- afternoon. This characteristic pattern has been attributed to underlying circadian rhythms and suggests working during the circadian trough in alertness is associated with an increased risk of accident (Brown 1994; Couper 1996; Folkard 1997; Mitler et al. 1988; Sanquitst et al. 1996; Summala & Mikkola 1994).

While in the past, only a small proportion of marine incidents were thought to be fatigue related, more recent information has suggested otherwise. For example, the US Coast Guard Research and Development Centre identified that 16 percent of critical vessel casualties and

33 percent of personnel injury casualties in US Coastal waters between 1 July and 31 December 1995, had some fatigue contribution (McCallum et al. 1996). These figures were more than 10 times greater than the estimates established from data collected in 1993 (1.2 percent and 1.3 percent for vessel casualties and personnel injuries respectively) (McCallum et al. 1996).

There is continuing research activity designed to develop a greater understanding of the relationship between sleep, fatigue and transportation accidents. This research has identified a number of work conditions which significantly contribute to fatigue-related incidents. Some of the conditions include the number of consecutive days work prior to an incident, the number of days worked in the 30 days prior to an incident, hours on duty prior to the incident and hours worked in the past 24, 48 or 72 hours (McCallum et al. 1996). Additionally, duration of the last sleep period, total number of hours slept during the 24 hours prior to an incident and whether or not a split sleeping schedule had been adopted are important predictors of fatigue-related accidents (National Transportation Safety Board 1995).

Of particular concern to regulatory bodies such as the Australian Maritime Safety Authority is the potential impact the work characteristics of Great Barrier Reef pilots may exert on fatigue. This retrospective analysis of the work schedules of Great Barrier Reef pilots will provide a basic description of the work patterns of Great Barrier Reef pilots in terms of ship and non-ship time. Additionally, the analysis will identify the presence and extent of potential fatigue indicators, such as duration of work and rest and the placement of these within the 24 hour cycle.

Section 3 - methods

3.1 Aims

The aims of the retrospective analysis of the work schedules were to: (i) develop a basic description of the work patterns of Great Barrier Reef pilots based on ship and non-ship times, (ii) incorporate and assess the impact of work-related travel time into the description of the work patterns; (iii) identify aspects from the work schedules which may be related to fatigue while working on the bridge; and (iv) identify factors which may enhance the present work schedule reporting

3.2 Measures

The primary measures included: (i) the number of tours of duty, (ii) number of work assignments, (iii) breaks between tours of duty, (iv) breaks between work assignments; and (v) night time hours. Definitions of the key measures are shown in Table 3.0.

Table 3.0 *Definition of key measures*

Measure	Definition
Tour of duty	One or more work assignments defined by the time between the first embarkation to the last disembarkation. Tours were delineated according to breaks between assignments: when there were 7 or more days break between consecutive work assignments it was determined that a new tour had commenced; 3 or fewer days break between work assignments were considered to represent a continuation of a tour; 3-7 days breaks were individually assessed
Work assignment	A continuous period of time when a pilot is on board ship measured from embarkation to disembarkation and adjusted for travel to and from the ship.
Breaks between work assignments	A continuous period of time extending from disembarkation to embarkation (ie non-ship time).
Day and Night Time Periods	Specification of daytime and night time periods was based on civil twilight hours averaged across 12 months and three areas in the Great Barrier Reef region. The day time period extended from 0525 to 1818 hours.

Further details of the calculation of primary measures are shown in Appendix A.

The work schedule files contained data on all work assignments performed across the 18 month period from January 1 1996 to June 30 1997 by Great Barrier Reef pilots. Information in the work schedules relevant to the study included company code, date, time and location of embarkation and disembarkation, shipping route travelled and type of vessel piloted. The work schedule files, which are compiled by the pilotage companies from invoices submitted by pilots on the completion of work assignments, were supplied to the researchers by the Australian Maritime Safety Authority, with full cooperation from the companies.

All measures were based on the sample sizes shown in Tables 3.1, 3.2 and 3.3. In total, data from 4310 work assignments completed during 902 tours of duty by 64 pilots was available.

Table 3.1 *Number of pilots, tours of duty and work assignments for Company A for each 6 month period.*

Time period *	No of Pilots	No of Tours	No of Work Assignments
Period 1	29	122	534
Period 2	29	152	735
Period 3	30	145	657

Table 3.2 *Number of pilots, tours of duty and work assignments for Company B for each 6 month period.*

Time period *	No of Pilots	No of Tours	No of Work Assignments
Period 1	27	147	677
Period 2	28	141	851
Period 3	26	159	790

Table 3.3 *Number of pilots, tours of duty and work assignments for Company C for each 6 month period **.*

Time period *	No of Pilots	No of Tours	No of Work Assignments
Period 1	2	2	2
Period 2	3	17	28
Period 3	3	17	26

Note:

- Period 1 = 1.01.96-30.06.96
- Period 2 = 1.07.96-31.12.96
- Period 3 = 1.01.97-30.06.97

* The time period corresponding to the period in which the work assignment or tour began.

** Company C's operations began in the first time period and take place in one region (Hydrographers Passage). In Period 1, two pilots in Company C each did one tour comprising only one work assignment. 838 tours of duty were used to calculate breaks between tours. 64 tours and work assignments were not used in break calculation as the break duration was not available for the first tour or work assignment.

3.3 Travel

Great Barrier Reef pilots engage in substantial amounts of work-related travel and hence, one of the aims of the study was to assess the impact of travel on work patterns. Accordingly, the work schedule files were adjusted to incorporate data on travel. The three types of travel data input into the work schedule file were: (I) travel to and from tours of duty; (ii) travel to and from embarkation and disembarkation grounds (boarding grounds located off shore); and (iii) travel between work assignments. In consultation with Great Barrier Reef pilot advisory group members, only travel to and from ships and between work assignments was considered to constitute work. The duration of the travel to and from tours of duty and between work assignments was determined from standard airline schedules, while travel times to and from embarkation and disembarkation were provided by the pilotage companies. All travel times were confirmed by Pilot Advisory Group members. Waiting times at airports and boarding grounds were not included in the analysis and thus, the estimates of travel times were likely to be conservative.

3.4 Data analysis

The data analysis assessed differences between companies and shipping routes, as well as across the 18 month analysis period. To assess changes across time, the 18 month period was divided into three 6 month periods. The results have been presented as means and standard errors, with analysis of variance (ANOVA) being used to determine between company and time period differences. When significant differences were present, post hoc testing was used to determine the source of the differences. Additionally, frequency distributions of the key measures have been used to show the amount of variability within the data set and to identify extreme deviations from mean values.

In the tables giving the results of the ANOVA models, means (and standard errors of the mean) are presented. These were based on the fitted ANOVA model so that, for example, the reported company means have been adjusted for any differences in the way the workloads of the companies were spread over the three time periods. On some occasions however, the adjusted means were not able to be estimated. In these cases the unadjusted company means ignoring the time periods have been reported. In most cases there was little difference between such adjusted and unadjusted means.

The effect of incorporating travel time into the calculation of the key measures was assessed using either paired t-test or non parametric comparisons of frequency distributions. In all but one case, the incorporation of travel made a highly significant difference which was operationally important. For example, there were significant travel effects on the duration of assignments, duration of breaks between assignments and the proportion of the work assignment performed at night. Travel time has therefore been incorporated into key measures.

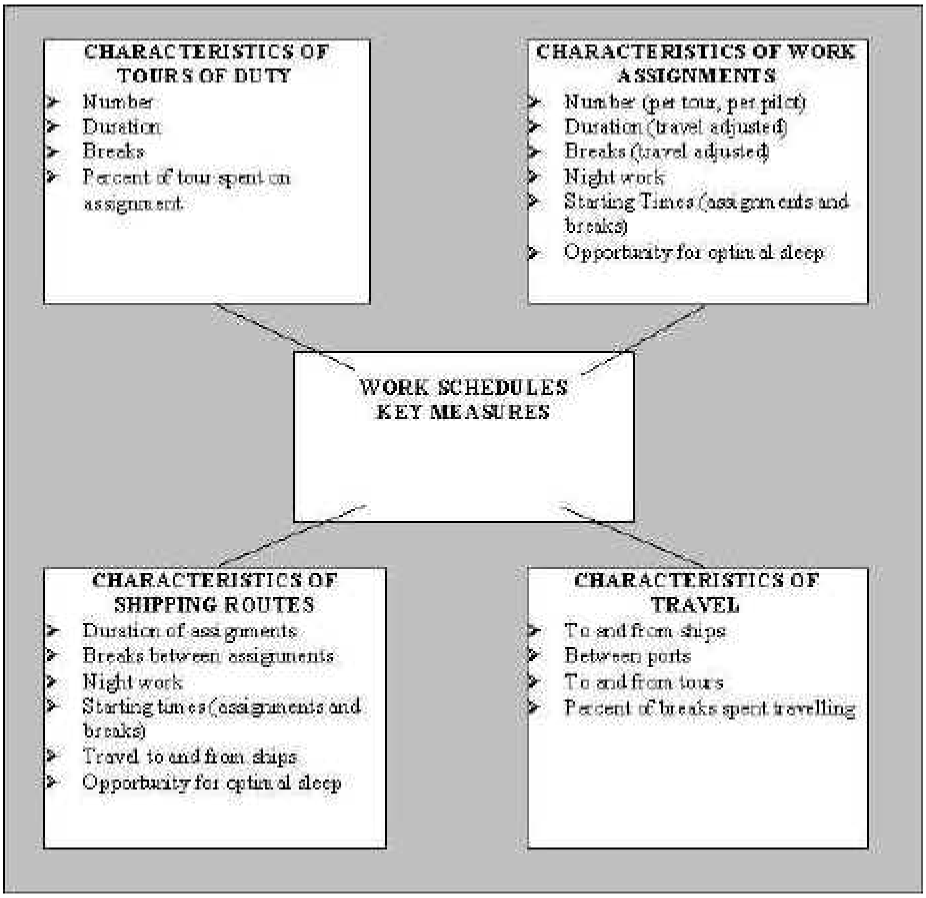
In order to exercise some control over the number of spuriously significant results arising from the large number of statistical tests undertaken, while at the same time minimising the risk of ignoring potentially important differences, only p-values less than 0.01 are considered statistically significant in this report.

The differences in operations between the three pilotage companies servicing the Great Barrier Reef -Torres Strait region, make inter-company comparisons of the present results somewhat difficult. Company C operate only on Hydrographers Passage and therefore have distinctly different work patterns as compared to Companies A and B, both of which operate throughout the entire Great Barrier Reef -Torres Strait region. As a consequence, inter-company comparisons mostly involve the two companies with similar operational procedures (i.e. Companies A and B). Wherever possible comparisons with relevant published findings are shown.

3.5 Presentation of results

The results are presented in four sections: (i) tours of duty; (ii) work assignments; (iii) shipping routes; and (iv) a description of travel. The schematic diagram below presents the key measures in each of these sections.

Figure 3.0 *Schematic diagram of key measures from the retrospective work schedules*



4.0 Results and discussion

A tour of duty consists of one or more work assignments and represents a continuous period during which the pilot alternates between working at sea and living ashore. Time spent ashore during a tour is frequently spent away from home, living in alternate accommodation such as hotels, motels or pilot houses. Following a tour of duty, the pilot returns home and usually takes a somewhat extended break from work (i.e. 5 or more days off work). For a complete definition of a tour of duty see Table 3.0.

4.1 Number of tours of duty

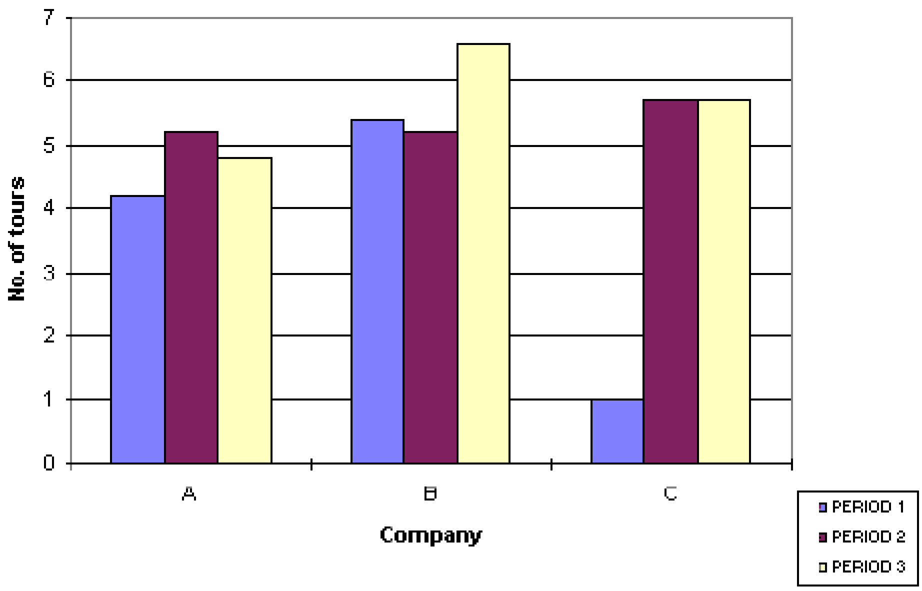
Figure 4.0 displays the mean number of tours of duty per pilot in the three time periods, for each company separately. Table 4.0 summarises the analysis of this data in terms of differences between companies and between the three 6-month periods. There were significant differences between the companies in the mean number of tours performed. Post hoc analysis indicated Company B personnel undertook more tours (5.68) than either Companies A (4.76) or C (4.11), which were statistically similar. The small number of tours recorded for Company C in the first 6-month period of the work schedule files relates to the establishment of this pilot company during this time (Figure 4.0).

Assessment of the number of tours of duty performed per pilot over the three 6-month periods revealed no significant differences over the 18 months. This pattern was exhibited by each of the pilot companies (Table 4.0).

Given that the central focus of the present study is to examine the fatigue aspects of the work practices of Great Barrier Reef pilots, it was considered important to identify situations where personnel undertook considerably more tours than depicted by average company figures. Hence, Figures 4.1a and Figure 4.1b present the number of tours of duty per pilot per period for Companies A and B respectively as frequency distributions. Clearly identifiable from these figures is that most pilots performed between 4 and 7 tours of duty per 6-month period. However, there was a minority group of pilots in both companies who undertook considerably more tours of duty per period. As it is those pilots performing greater than average amounts of work who are most likely to be susceptible to fatigue and decreased performance (Iskra-Golec et al. 1996; Rosa et al. 1989; Spurgeon et al. 1997), monitoring of extreme levels of work should be undertaken

Other differences noted in the frequency distributions are that considerably more pilots from Company B performed tours in the upper end of the distribution (e.g. between 8 and 10) than their colleagues in Company A. The small number of pilots in Company C made it inappropriate to show the distribution for this group.

Figure 4.0 *Mean number of tours of duty per pilot, by company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 4.0 *Analysis of the mean number of tours of duty per pilot (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			5.45	0.0051
A	1	4.76 (0.197)		
B	2	5.68 (0.208)		
C	1	4.11 (0.664)		
Period (main effect)			3.56	0.0306
1	n/a	3.55 (0.465)		
2	n/a	5.38 (0.391)		
3	n/a	5.62 (0.392)		
Company * Period interaction			3.15	0.0158

Notes

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.

2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01) n/a Post hoc testing not performed when main effects not significant.

Company (Main Effect). This term measures whether or not there is a difference between companies averaged across the three time periods.

Period (Main Effect). This term measures whether or not there is a difference between the periods averaged across the companies.

Company * Period Interaction. This term measures whether or not the difference between the companies is the same in each period. Equally, it measures if the difference between periods is the same for each company. When the interaction is statistically significant there is little interest in the main effects. In this case averages over one of the factors ignore important variations.

Figure 4.1a *Frequency distribution - Number of tours of duty per pilot - Company A*

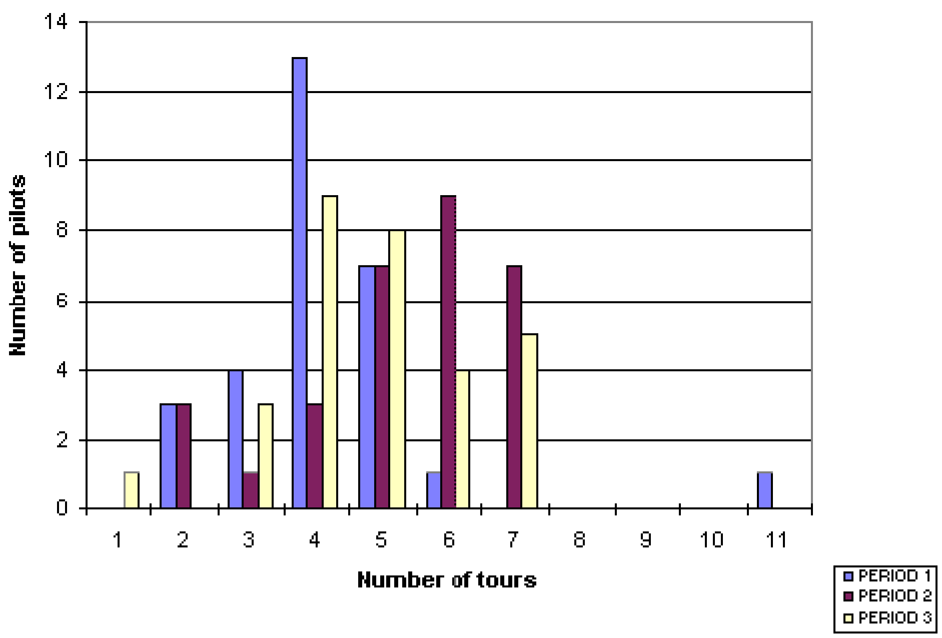
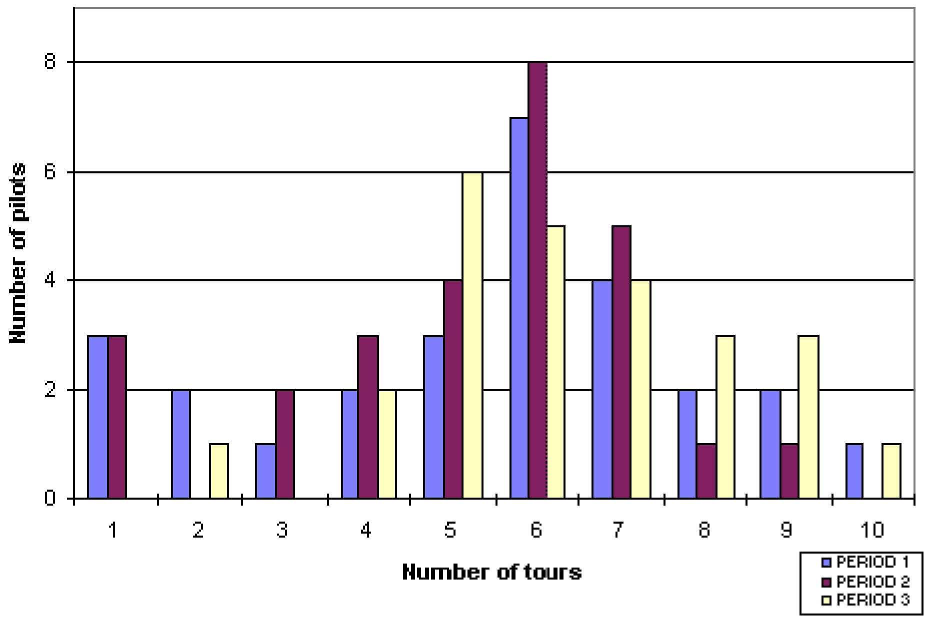


Figure 4.1b *Frequency distribution - Number of tours of duty per pilot - Company B*



4.2 Duration of tours of duty

The mean duration of tours across the three 6-month periods for each of the companies separately is illustrated in Figure 4.2. Analysis of between company and time period differences in this data is displayed in Table 4.1. Significant between company differences in mean tour duration existed and relate to the shorter tours performed by Company C (2.8 days) compared with Companies A (18.0 days) and B (17.2 days), which were similar. The considerably shorter duration of tours performed by pilots in Company C reflects the single operational region of this group (i.e. Hydrographers passage only). In contrast, pilots in Company A and B operate in three pilotage regions (Hydrographers passage, the Inner Route and the Great North East Channel) and hence receive a greater volume of work and tend to spend longer periods away from home.

When presenting the data for each company as frequency distributions (Figures 4.3a, Figure 4.3b and Figure 4.3c), it is evident that for both Companies A and B, tour duration varied greatly. Some tours were as short as 1 day in duration while other tours extended up to 35 days in duration. In contrast, much less variability existed in the data for Company C, with all tours performed by this company during the analysis period ranging between 1 and 15 days in duration. These inter-company differences are consistent with the mean data and most likely reflect the distinct operational differences between the pilotage groups.

Several possible factors may have contributed to the wide range of variability which existed in tour duration of Companies A and B. Firstly, it is likely that to a certain extent, tour duration reflects work availability. When shipping demands decrease and consequently, work availability is low, it could be anticipated that shorter tours would be engaged in whereas during extremely busy periods, tour duration would be expected to correspondingly increase.

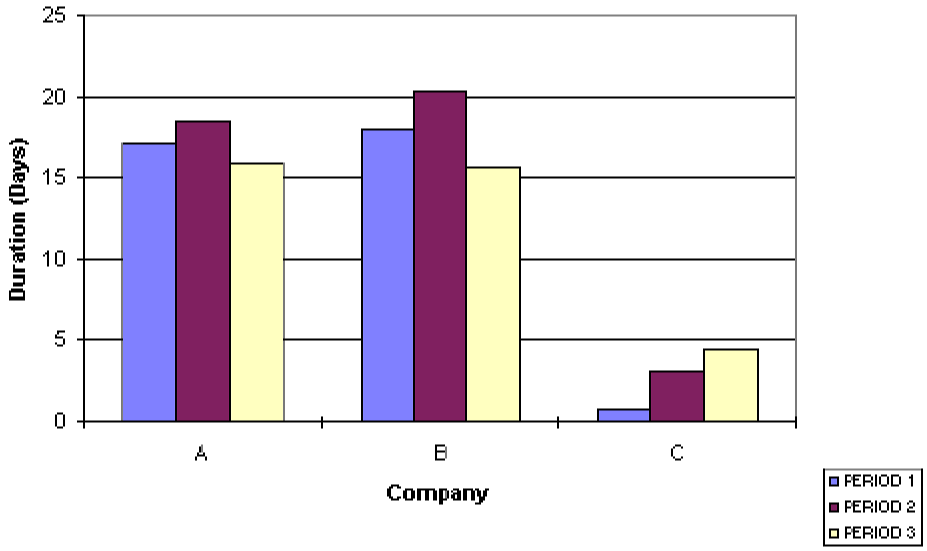
Secondly, it is possible that the pilot's location of residence may influence tour duration. For those pilots living in or close to operational regions, shorter tours of duty may be performed given the greater accessibility and convenience of returning home between work assignments. On the other hand, pilots who reside distant from their work locality may undertake longer tours of duty due to the additional expense and time associated with returning home.

Thirdly, tour duration may be related to the amount of notification pilots receive prior to beginning work. In situations when pilots are called upon at short notice to perform unexpected work during busy periods, tours of duty may be decisively shorter than when pilots have been informed with ample time to prepare themselves for upcoming work assignments.

Across the three 6-month periods there were significant differences in the duration of tours (Table 4.1). Post hoc analysis revealed that tours during the second 6-month period were significantly longer (13.98 days) than tours during the third six month period (12.01 days). No clear conclusion with regards to the first period was obtained from post hoc testing. As post hoc analysis incorporates sample size and variance, the lack of conclusions for this period may be related to these factors. The finding that mean tour duration increased in the second period applied to all of the companies, and may suggest that the total volume of shipping in all operational regions increased during this time.

To further explore the potential fatigue aspects of the work practices of Great Barrier Reef pilots, total time spent on tours of duty per pilot was determined (Table 4.0 and Table 4.1). During each 6 month period, it was evident that Company A pilots spent ~ 81 days on tour, Company B pilots ~ 102 days and Company C pilots ~ 11 days. Caution should be taken when interpreting these findings as at this stage of the analysis no breakdown of the amount of time spent working and resting during a tour has been incorporated. However, it is possible the extra 21 days of tour time per 6 month period for Company B personnel compared with Company A pilots, may contribute to increased fatigue and warrants further consideration. The work practices of Company C seem to be least problematic in terms of fatigue potential related to tour number and duration.

Figure 4.2 *Mean duration of tours (days), by Company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 4.1 *Analysis of the mean duration of tours of duty (days) (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			27.31	0.0001
A	1	17.17 (0.549)		
B	1	18.00 (0.530)		
C	2	2.77 (2.931)		
Period (main effect)			7.09	0.0009
1	1/2	11.95 (2.677)		
2	1	13.98 (1.004)		
3	2	12.01 (1.001)		
Company * Period interaction			0.75	0.5561

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01).

Company (Main Effect). This term measures whether or not there is a difference between companies averaged across the three time periods.

Period (Main Effect). This term measures whether or not there is a difference between the periods averaged across the companies.

Company * Period Interaction. This term measures whether or not the difference between the companies is the same in each period. Equally, it measures if the difference between periods is the same for each company. When the interaction is statistically significant there is little interest in the main effects. In this case averages over one of the factors ignore important variations.

Figure 4.3a *Frequency distribution - Duration of tours (days) per period - Company A*

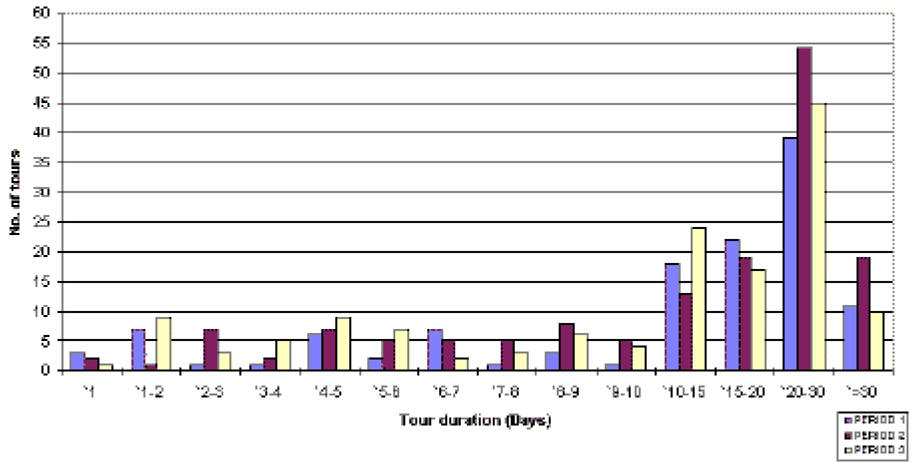


Figure 4.3b *Frequency distribution - Duration of tours (days) per period - Company B*

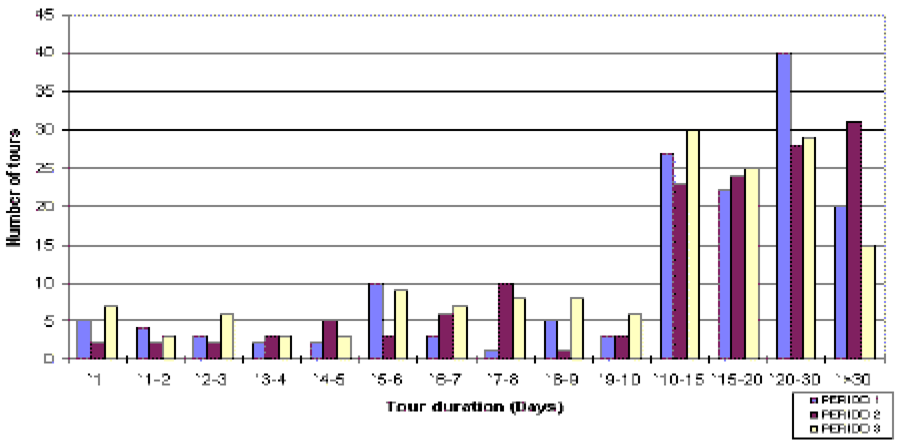
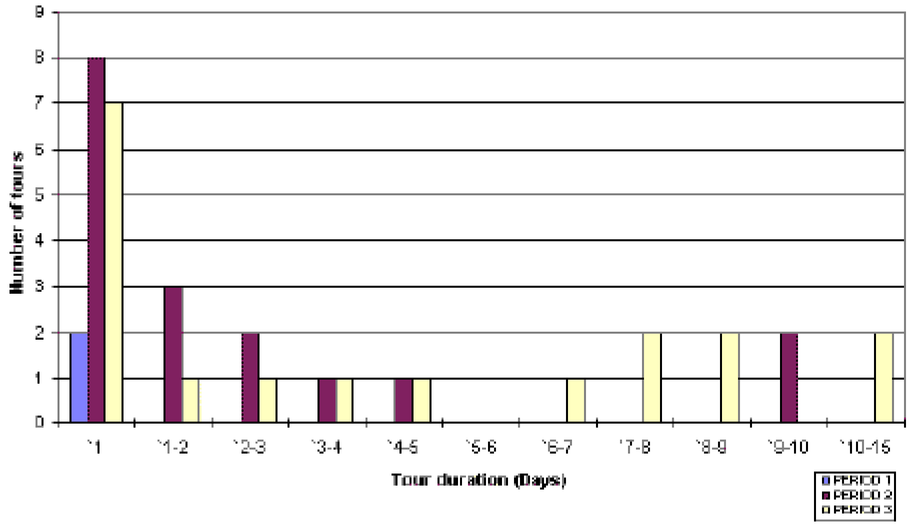


Figure 4.3c *Frequency distribution - Duration of tours (days) per period - Company C*



4.3 Duration of breaks between tours of duty

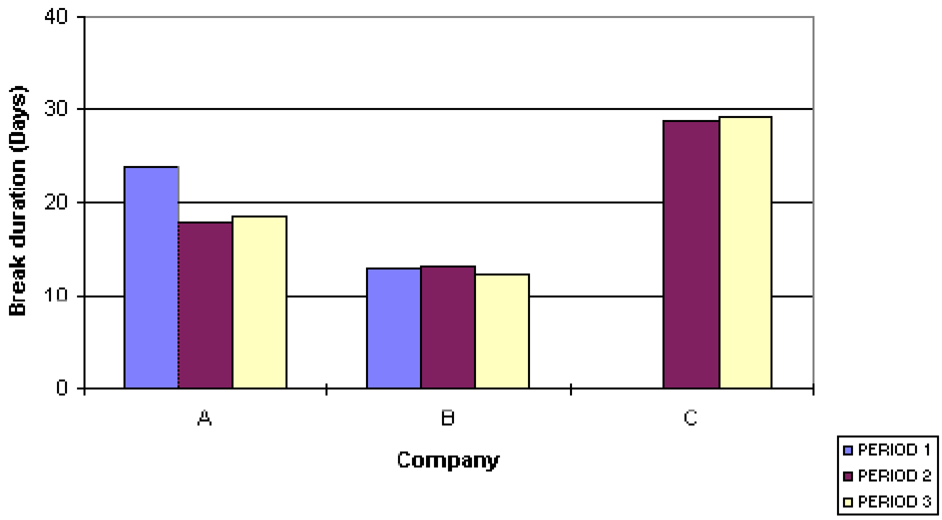
Breaks between tours potentially represent time for pilots to spend at home relaxing and recuperating between one tour of duty and another. Previous research based on populations involved in home and away occupations indicates that such breaks provide the opportunity to spend highly valued time with family and friends (Parker et al. 1997; Sutherland & Flin 1989).

For each of the pilotage companies the mean duration of breaks between tours in the three 6-month periods are displayed in Figure 4.4. An analysis of the company and period differences in this data is shown in Table 4.2. Significant differences existed, with pilots from Company C experiencing the longest tour breaks (28.0 days), followed by pilots from Company A (19.5 days) and then pilots from Company B (12.8 days). This pattern of results is also clearly evident when the data is presented as frequency distributions (Figure 4.5a, Figure 4.5b and Figure 4.5c). The distribution curve for Company C is markedly skewed (Figure 4.5c) indicating that the majority of tour breaks were 20 days or longer in duration, whereas relatively few tour breaks experienced by Company B personnel exceeded 15 days duration (Figure 4.5b). These results are consistent with the findings reported in section 4.2 showing that during each 6 month period, Company C pilots spent less time on tour whereas Company B pilots spent more time on tour.

That a considerable number of pilots working for Company B live in or adjacent to the operational region (North and Central Queensland) may be one explanation for the significantly shorter duration of tour breaks experienced by this group. It is possible that pilots living in closer proximity to the working regions may be more frequently called upon to do work at short notice. Consequently, breaks between tours may be reduced, and tours of duty were not as clearly delineated for those living close to work locations.

There were no significant differences across the three time periods in the length of breaks (Table 4.2). This result was observed for each company.

Figure 4.4 *Mean duration of breaks between tours (days), by Company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 4.2 *Analysis of the mean duration of breaks between tours of duty (days) (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			25.63	0.0001
A	1	19.49 (0.836)		
B	2	12.77 (0.841)		
C	3	28.00 (2.848)		
Period (main effect)			2.11	0.1218
1	n/a	17.73 (1.342)		
2	n/a	16.26 (0.992)		
3	n/a	15.97 (0.871)		
Company * Period interaction			1.55	0.2011

- (1) Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.

- (2) Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01) n/a Post hoc testing not performed when main effects not significant.

Company (Main Effect). This term measures whether or not there is a difference between companies averaged across the three time periods.

Period (Main Effect). This term measures whether or not there is a difference between the periods averaged across the companies.

Company * Period Interaction. This term measures whether or not the difference between the companies is the same in each period. Equally, it measures if the difference between periods is the same for each company. When the interaction is statistically significant there is little interest in the main effects. In this case averages over one of the factors ignore important variations.

Figure 4.5a *Frequency distribution - Duration of tour breaks (days) per period - Company A*

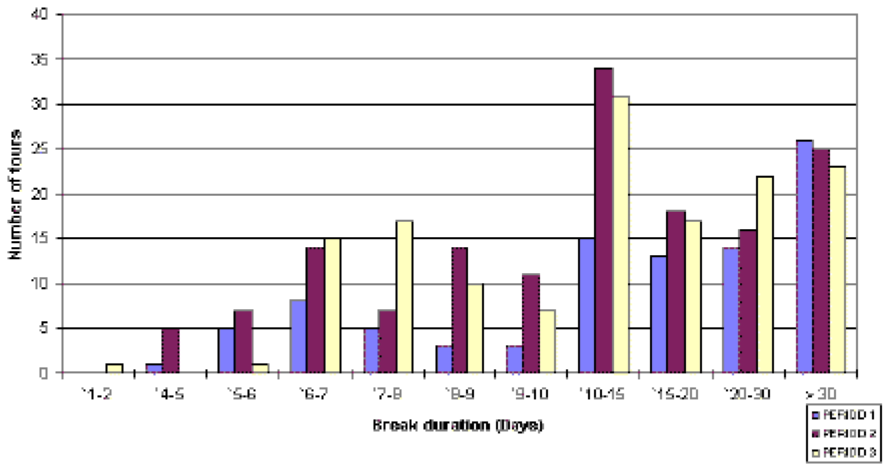


Figure 4.5b *Frequency distribution - Duration of tour breaks (days) per period - Company B*

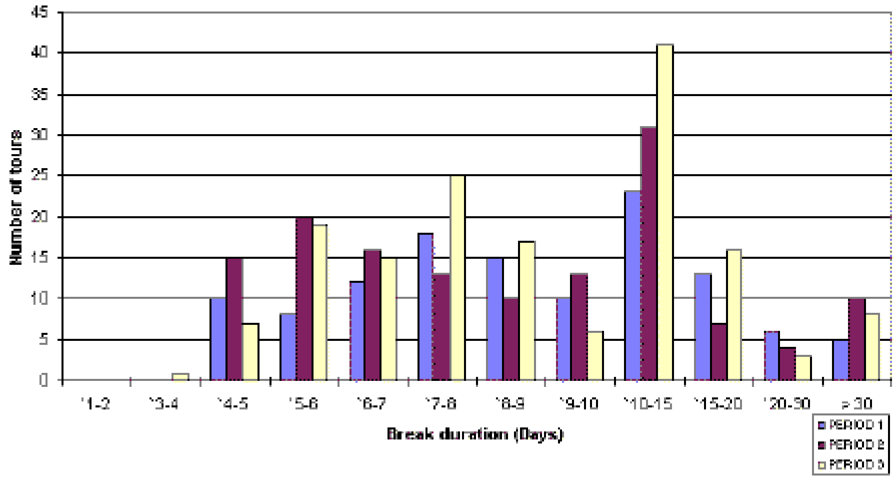
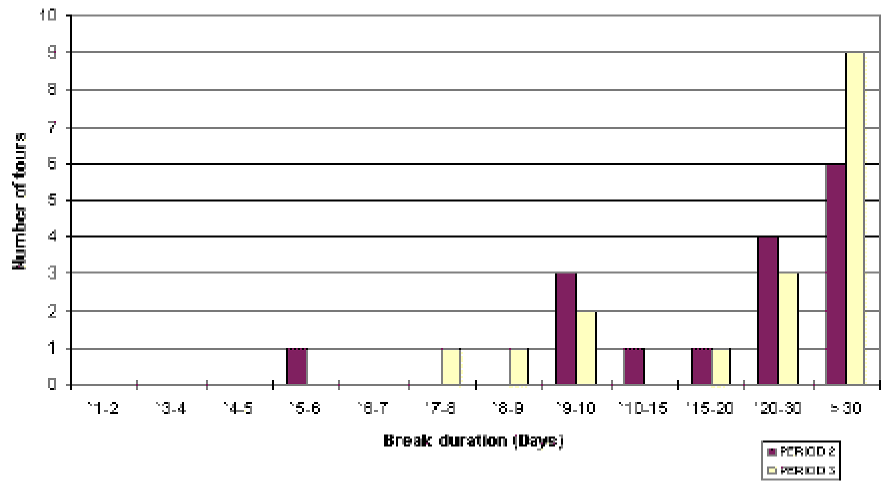


Figure 4.5c *Frequency distribution - Duration of tour breaks (days) per period - Company C*



4.4 Percent of tour time spent on work assignments

To assess the relative amount of time spent undertaking work assignments (ship time) while on a tour, the percent of tour spent on assignment was determined. Figure 4.6 illustrates this information for each company and time period separately, while Table 4.3 summarises the analysis of company and period differences in this data. On average, Company C pilots spent 72% of tours on work assignments whereas pilots from Companies A and B spent 56% and 53% respectively. However these differences between the companies failed to reach statistical significance. This may have been related to the large standard error associated with Company C's data.

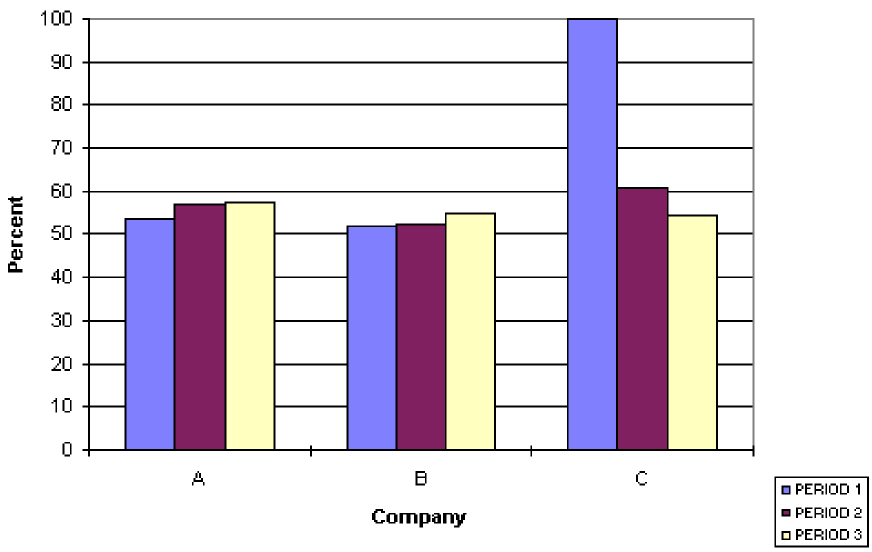
By presenting percent of tour spent on work assignments as frequency distributions (Figure 4.7a, Figure 4.7b and Figure 4.7c), further insight into the company mean figures is obtained. Data for both Companies A and B presents classical bell shaped curves, thereby suggesting that in the majority of situations approximately half of tour time is spent working on assignments and the other half is spent ashore resting and travelling to the next port location. In contrast, data for Company C presents as two distinct groups. Firstly, there were a substantial number of tours in which 90 - 100% of tour time was spent on assignments, whereas secondly, a number of tours during the second and third time periods involved only 10 - 40% of tour time being spent on assignments. Hence, tours of Company C tended to be much more variable, with some tours involving most, if not all time being spent on work assignments while other tours involved relatively little time being spent on the ship.

That Company C is only a small, newly established company operating in a single pilotage region undoubtedly contributes to these findings. Thus, in situations when only a single work assignment is to be performed during a tour, it is most likely that pilots would spend very little time ashore before returning home thereby accounting for those tours where 90 - 100% of tour time was spent on assignment. On the other hand, if pilots undertook 2 or more work assignments during a tour, the combination of a relatively short transit time through Hydrographers Passage, the need to meet minimum rest requirements between work assignments and the need to wait ashore for the next ship would account for those tours in which only 10 - 40% of tour time was spent working.

The bell shaped distributions presented for Companies A and B most likely relates to the greater number of pilots working for these companies, the more extensive operating regions and the larger volume of work performed. Additionally, the similarity between these two companies in terms of relative amount of tour time spent on work assignments reflects their similar operational regions.

There were no significant differences in the percent of tour time spent on work assignment across the three 6 month periods (Table 4.3). This temporal pattern was observed for all three companies.

Figure 4.6 *Mean percent of tour time spent on work assignments, by company and period*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 4.3 *Analysis of the mean percent of tour spent on work assignments (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results [2]	Mean (sem)	F Statistics	p-value
Company (main effect)			3.87	0.021
A	n/a	55.96 (0.975)		
B	n/a	52.94 (0.941)		
C	n/a	71.63 (5.206)		
Period (main effect)			1.24	0.290

1	n/a	68.49 (4.754)		
2	n/a	56.61 (1.784)		
3	n/a	55.43 (1.778)		
Company * Period interaction			2.94	0.019

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01) n/a Post hoc testing not performed when main effects not significant.

Figure 4.7a *Frequency distribution - Percent of tour time spent on work assignments per period - Company A*

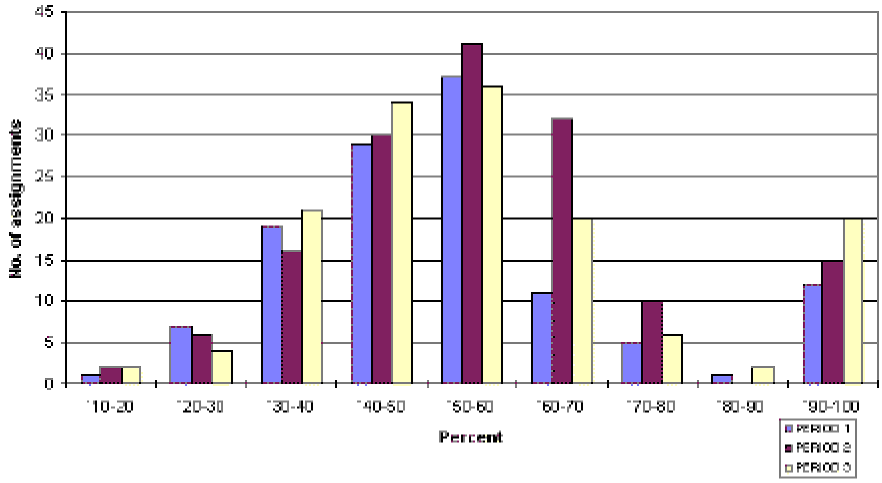


Figure 4.7b *Frequency distribution - Percent of tour time spent on work assignments per period - Company B*

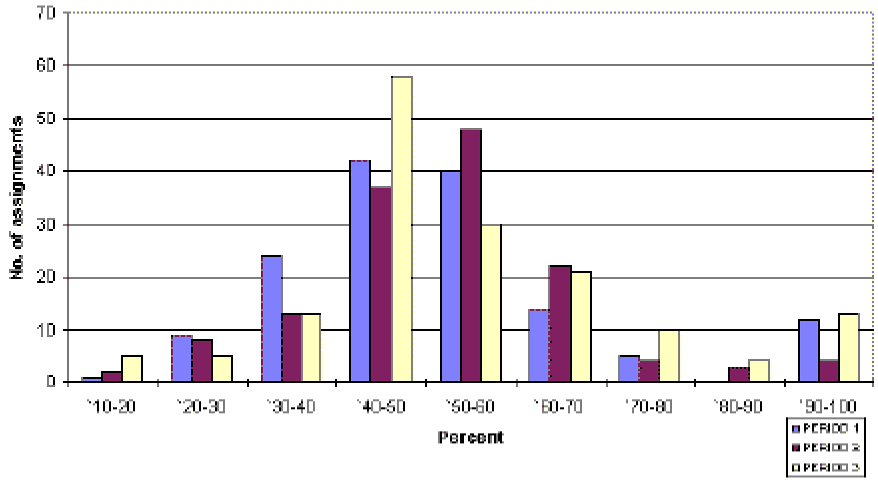
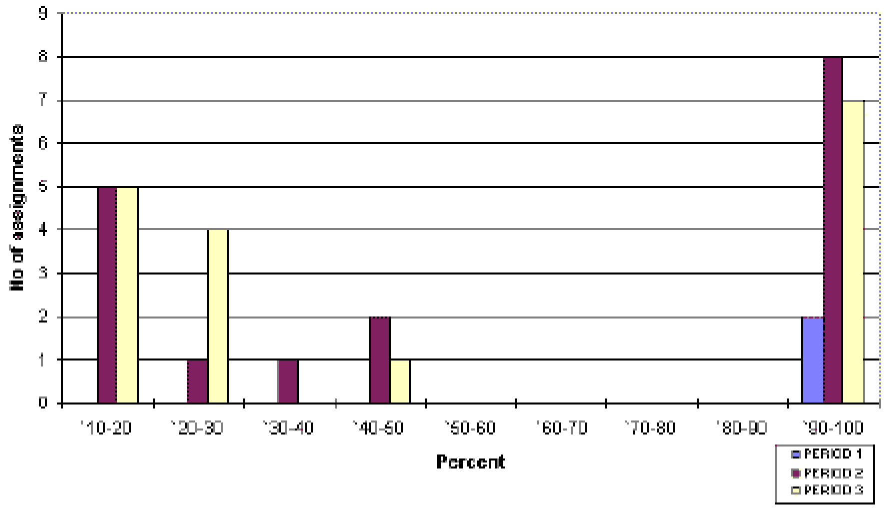


Figure 4.7c *Frequency distribution - Percent of tour time spent on work assignments per period - Company C*



4.5 Summary

One of the principle issues to be investigated by the present study is how the work practices of Great Barrier Reef pilots impact on fatigue. In line with this focus, an assessment of the number and duration of tours of duty, length of breaks between tours and percent of tour time spent on work assignments was undertaken. Clearly evident from these assessments was that Company C pilots performed significantly shorter tours, had longer rest breaks between tours and spent a greater percentage of tour time on work assignments, than pilots from Companies A and B. These findings most likely relate to the distinct differences in operations of Company C. This company is only a small, newly established company, operating in only a single pilotage region. As a consequence, work tends to be somewhat more sporadic, as is reflected by the present findings.

More meaningful inter-company comparisons can be made between Companies A and B, as these two companies have similar operations. With regards to mean data it was apparent that pilots working for Company B spend more time on tours and receive less time off between tours during each 6-month period, as compared to their colleagues working for Company A. Given that longer work hours and shorter rest breaks may place personnel at a greater risk of experiencing fatigue (Iskra-Golec et al. 1996; Rosa et al. 1989; Spurgeon et al. 1997), these findings warrant further examination. Caution should be observed when making judgments regarding the impact of fatigue based solely on the characteristics of tours of duty, as many other features of work patterns influence the fatigue state of an individual. Some of these features will be addressed in the following sections. Companies A and B recorded similar figures when percent of tour spent on work assignments was analysed, thereby confirming the similar operations of these two groups.

While mean data is useful in providing a general description of the data set, it fails to highlight the variability which exists within the data. For this reason, some of the measures examined in the present study have been presented as frequency distributions. This enables the identification of situations in which pilots are undertaking greater than the average amount of work, and hence, have an increased risk of fatigue development.

When the number and duration of tours per pilot per 6 month period and length of breaks between tours were presented as frequency distributions, it was evident that there were several pilots from Companies A and B who performed a considerably greater than average number of tours and experienced shorter breaks between tours during the analysis period. Such workloads are associated with a heightened fatigue potential. Thus, in order to ensure sufficient recuperation between tours of duty and prevent the development of fatigue, monitoring of extreme levels of work should be undertaken. The small company size and irregularity of work performed by Company C resulted in the frequency distributions for this group showing large amounts of variability.

Changes across time were evident in tour duration, with longer tours being undertaken during the second time period. This finding was observed for all of the companies suggesting that the total volume of shipping increased during this period.

5.0 Results and discussion

Work assignments were clearly identifiable from the work schedule files and were measured from the date and time of embarkation to the date and time of disembarkation (i.e. time on the ship). At this stage of the analysis no attempt has been made to split time on the ship into work on the bridge and rest; on tour logs will provide this specific information.

5.1 Number of work assignments per tour

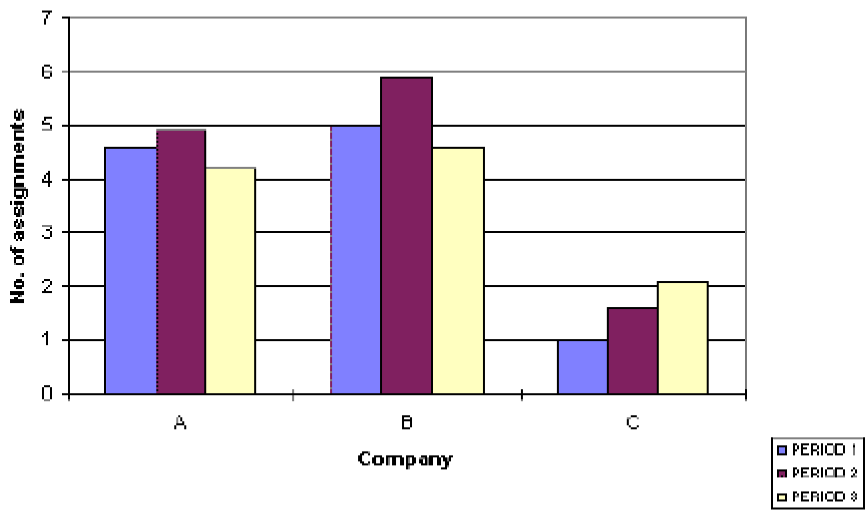
For each of the pilotage companies across the three 6-month periods, the average number of work assignments per tour is shown in Figure 5.0. Between company and time period differences from the analysis of this data are summarised in Table 5.0. The number of work assignments per tour differed significantly between the three companies. The greatest number of work assignments per tour were performed by Company B pilots (5.21) followed by Company A (4.59) and then Company C (1.59). The fewer number of assignments undertaken by Company C relates to the single operational region of this company.

By presenting the number of work assignments per tour as a series of frequency distributions (Figure 5.1a and Figure 5.1b), a clearer indication of the work patterns of Great Barrier Reef pilots can be obtained. For both Companies A and B, the frequency curves were fairly similar with most pilots performing 8 or fewer work assignments per tour. However, there were a number of situations for both companies in which considerably more work assignments were undertaken during a single tour, with some tours involving 14 or more work assignments. While unusual circumstances may have prevailed during these tours, the heightened risk of fatigue which exists in situations of extreme workload (Iskra-Golec et al. 1996; Rosa et al. 1989; Spurgeon et al. 1997) may justify closer monitoring of the number of work assignments being performed during tours.

When examining changes in the average number of work assignments per tour across the 18 months, a significantly greater number of work assignments (4.19) were performed in the second time period (Table 5.0). This trend is also evident on the frequency distributions (Figures 5.1a and Figures 5.1b), as most of the tours involving greater than average workloads were undertaken during the middle 6-month period. The same temporal pattern was observed for each company, thereby suggesting that the greater number of assignments in the second six months was a reflection of the dynamics in shipping volumes and available work. Personal communication with Pilot Advisory Group members (4 August, 1997) substantiates this suggestion.

The finding of significant variations in the amount of pilotage work across time highlights the unpredictability associated with marine pilotage work. Situations such as industrial disputation in mining areas in central and northern Queensland and the economic state of neighbouring Asian countries contribute to work fluctuations, as do seasonal variations in imports and exports (Personal Communication - Iain Steverson, 14 May, 1998). As a consequence, pilots are never really sure how much work will be available in the future. This uncertainty more than likely contributes to the stress experienced by Great Barrier Reef pilots with regards to financial income and job security (Personal Communication - Pilot Advisory Group, 4 August, 1997). It also makes the jobs of the pilotage company administrators more difficult when trying to ensure work is evenly distributed among the pilots and in the development of fatigue management plans (Personal Communication - Iain Steverson, 14 May, 1998).

Figure 5.0 *Mean number of work assignments per tour, by Company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 5.0 *Analysis of the mean number of work assignments per tour (1 Jan 1996 - 30 June 1997) (1)*

Effect	**Post hoc results (2)**	**Mean (sem)**	**F Statistics**	**p-value**
Company (main effect)			25.92	0.0001
A	1	4.59 (0.135)		
B	2	5.21 (0.132)		
C	3	1.59 (0.728)		
Period (main effect)			9.24	0.0001
1	1/2	3.54 (0.665)		
2	1	4.19 (0.249)		
3	2	3.66 (0.249)		
Company * Period interaction			1.27	0.281

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01)

Company (Main Effect). This term measures whether or not there is a difference between companies averaged across the three time periods.

Period (Main Effect). This term measures whether or not there is a difference between the periods averaged across the companies.

Company * Period Interaction. This term measures whether or not the difference between the companies is the same in each period. Equally, it measures if the difference between periods is the same for each company. When the interaction is statistically significant there is little interest in the main effects. In this case averages over one of the factors ignore important variations.

Figure 5.1a *Frequency distribution - Number of work assignments per tour by period - Company A*

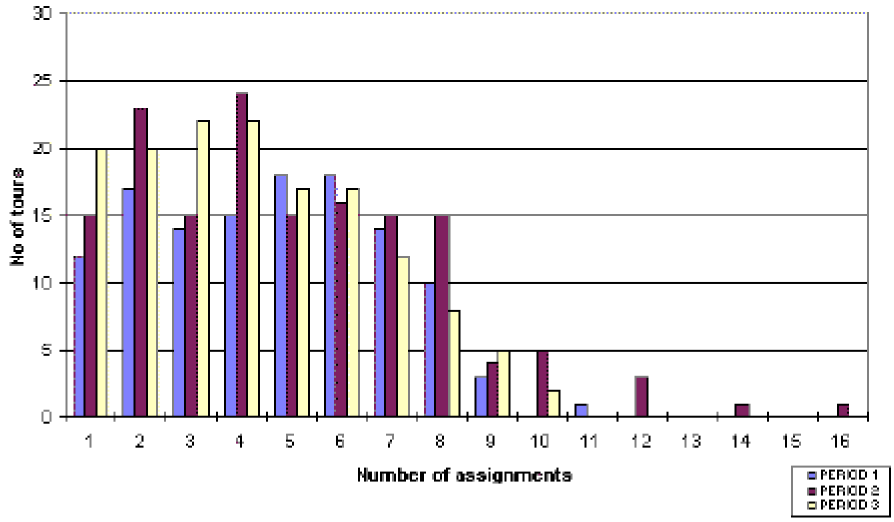
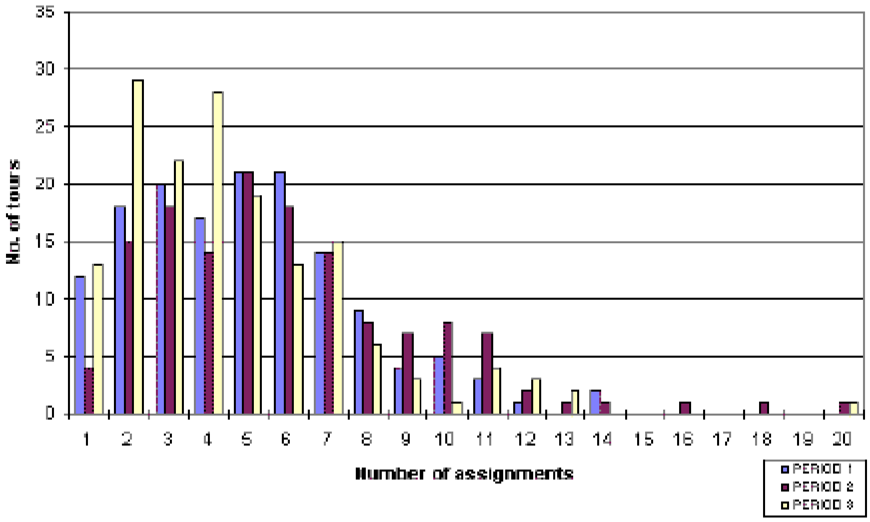


Figure 5.1b *Frequency distribution - Number of work assignments per tour per period - Company B*



5.2 Number of Work Assignments per Pilot

Presented in Figure 5.2 are the mean number of work assignments per pilot per six month period, for each company separately. Table 5.1 summarises the results of the analysis of this data in terms of company and period differences. The three companies differed significantly in the mean number of assignments performed per pilot; Company B pilots performed the greatest number of assignments (28.6), followed by Company A pilots (21.8) and then Company C pilots (7.4). When the two pilot groups with similar operational regions are compared (i.e. Companies A and B), these results indicate pilots working for Company B performed approximately 31% more work assignments than their colleagues in Company A. Such a finding is consistent with previous results indicating that Company B pilots spent more time on tours and had shorter breaks between tours during each 6 month period (Section 4). The smaller number of assignments per pilot performed by Company C reflects the single operational region of this company.

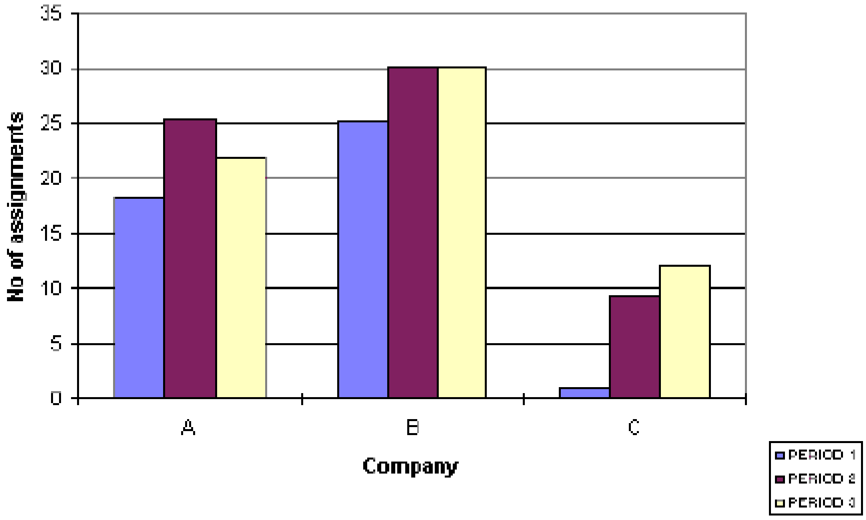
That pilots from Company B are undertaking significantly more work assignments per 6 month period compared with Company A personnel may be a reflection of increased commercial pressures generated by the privatisation of pilotage in the Great Barrier Reef - Torres Strait region. Competition between pilotage companies for work is now an integral part of Great Barrier Reef marine pilotage, with each company trying to secure enough work to make their operation economically viable. It is therefore possible that over the 18 month analysis period, Company B may have secured more work than Company A. The increased job security and financial benefits of this additional work would have undoubtedly been welcomed by Company B pilots. However, the increased risk of fatigue development associated with greater workloads and potential impact this may have on safety standards (Spurgeon et al. 1997) raises concern over the appropriateness of competition between pilot companies.

Concern over the issue of competition in pilotage operations was raised in a paper presented at a recent International Pilotage Conference held in Brisbane. The author indicated that competition is incompatible with compulsory pilotage; it is bad for the public, for the shipping industry and the pilotage profession. Competition may compromise safety, particularly when pilots are expected to exercise independent judgment and resist pressures, which are inconsistent with the interests of safety. Commercial pilotage operations may also lead to the provision of discriminatory service, and may be economically inefficient requiring duplication of many items of expense such as pilot launches and dispatch services (Sparks, 1998).

Post hoc analysis of changes across time (Table 5.1) revealed that significantly more work assignments were performed by pilots during the second 6-month period (21.4), as compared to the first period (14.8). Results for the third time period were inconclusive. These changes were similar for each of the pilotage companies and support the previous finding indicating increased work availability during the second time period. Consultation with pilotage company personnel indicated that the increase in shipping traffic during the period between July 1 and December 31 is an annual occurrence related to the sugar cane season in northern Queensland. However, as other factors also influence work availability such as industrial disputes and the economic state of neighbouring Asian countries, it is somewhat difficult to predict how much work will be available during any one period (Personal communication – Iain Steverson, June 10 1998).

By presenting the number of work assignments per pilot as frequency distributions (Figure 5.3a and Figure 5.3b), it is apparent that in both Companies A and B there were a number of pilots performing considerably greater workloads than what the company average figures depict. This was especially the case during the busy second 6 month period and for personnel from Company B. Given the increased fatigue potential of greater workloads (Iskra-Golec et al. 1996; Rosa et al. 1989; Spurgeon et al. 1997), the finding that there were personnel in both companies undertaking in excess of 35 work assignments per 6-months is disconcerting and implies that closer monitoring of the situations influencing the number of work assignments undertaken by pilots may be required.

Figure 5.2 *Mean number of work assignments per pilot, by Company and period (1 Jan 1996 -30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 5.1 *Analysis of the mean number of work assignments per pilot (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			26.11	0.0001
A	1	21.89 (0.943)		
B	2	28.62 (0.83)		
C	3	7.44 (3.184)		
Period (main effect)			7.78	0.0006
1	1	14.83 (2.228)		
2	2	21.69 (1.872)		
3	1/2	21.43 (1.876)		
Company * Period interaction			0.45	0.7740

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01)

Company (Main Effect). This term measures whether or not there is a difference between companies averaged across the three time periods.

Period (Main Effect). This term measures whether or not there is a difference between the periods averaged across the companies.

Company * Period Interaction. This term measures whether or not the difference between the companies is the same in each period. Equally, it measures if the difference between periods is the same for each company. When the interaction is statistically significant there is little interest in the main effects. In this case averages over one of the factors ignore important variations.

Figure 5.3a *Frequency distribution - Number of work assignments per pilot per period - Company A*

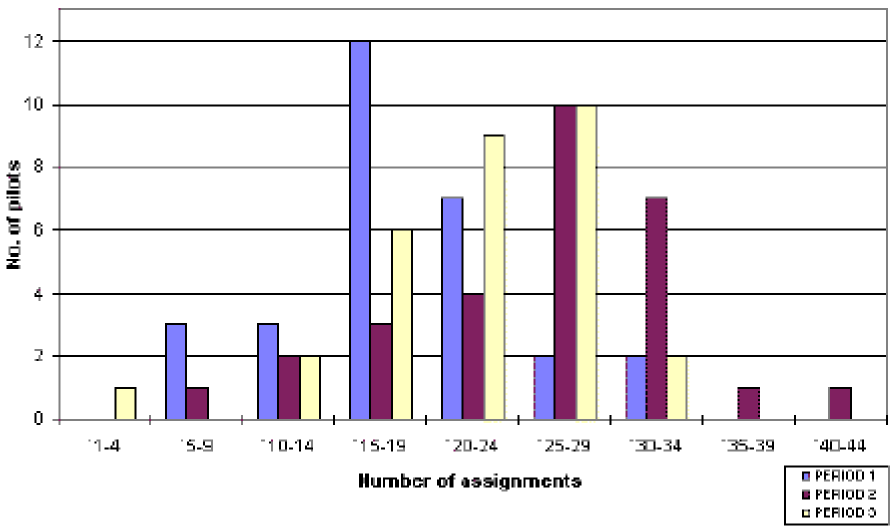
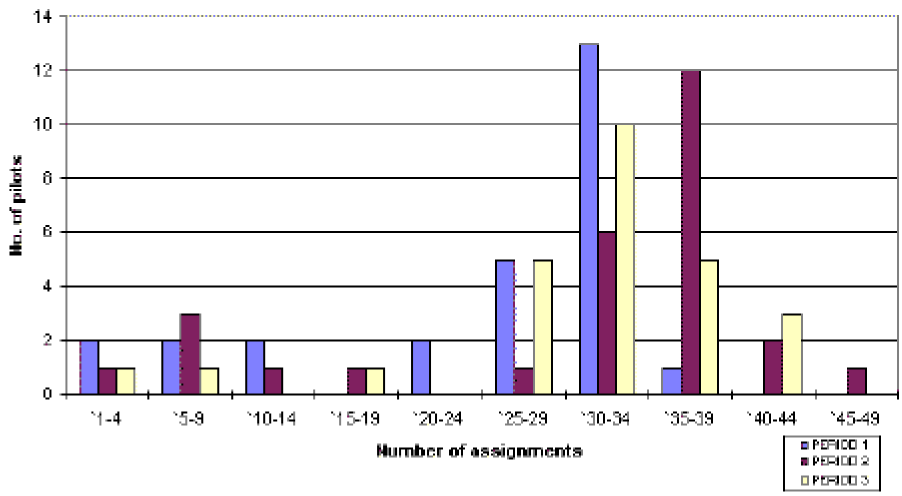


Figure 5.3b *Frequency distribution - Number of work assignments per pilot per period - Company B*



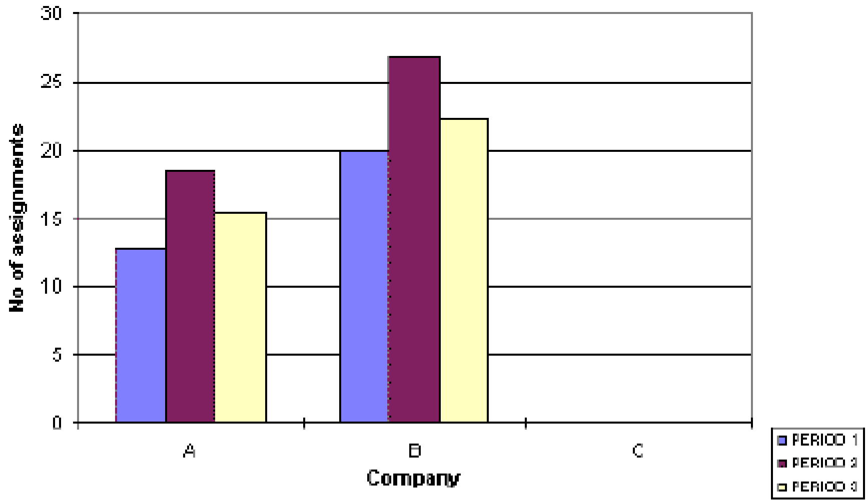
5.3 Number of Work Assignments per Pilot – Inner Route

Given the overall priority of the study to identify factors possibly associated with fatigue, a breakdown of work assignments by shipping route was undertaken. The section of the Inner Route which stretches between Cairns and Cape York, is a region of compulsory pilotage. Some characteristics of the Inner Route such as the longer duration of pilotage (up to 90 continuous hours) in combination with hazardous shipping conditions (tides and under keel clearance) have the potential to substantially increase stress and fatigue levels (Personal Communication - Pilot Advisory Group, 4 August, 1997).

Figure 5.4 shows time period and company results for the mean number of work assignments per pilot on the Inner Route. Results of the analysis of this data in terms of company and time period differences are shown in Table 5.2. Company C does not operate in this region and were therefore excluded from the present analysis. The number of work assignments undertaken on this shipping route was significantly greater for Company B pilots (23.6) than their colleagues in Company A (15.6). These figures reflect a 51% greater workload on the Inner Route for pilots of Company B. These results are also depicted by the frequency distributions (Figure 5.5a and Figure 5.5b) which show that substantially more pilots from Company B performed 25 or more assignments per 6-months on this shipping route, compared with Company A pilots.

In terms of changes across time in the number of assignments performed on the Inner route, significant differences existed. An average of 22.7 Inner Route passages were performed per pilot during the second 6-month period, as compared to 19 passages during the third 6-months and 16.4 during the first 6-months. These findings support previous results indicating increased work availability during the middle 6-month period of the analysis. The same temporal patterns in the number of assignments were observed in both companies.

Figure 5.4 *Mean number of work assignments per pilot on the Inner Route by Company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 5.2 *Analysis of the mean number of work assignments per pilot on the Inner Route (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			62.35	0.0001
A	1	15.67 (0.626)		
B	2	23.05 (0.702)		
C	n/a	n/a		
Period (main effect)			14.76	0.0001
1	1	16.37 (0.820)		
2	2	22.67 (0.820)		
3	1	18.96 (0.804)		
Company * Period interaction			0.18	0.8327

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.

2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01).

Company (Main Effect). This term measures whether or not there is a difference between companies averaged across the three time periods.

Period (Main Effect). This term measures whether or not there is a difference between the periods averaged across the companies.

Company * Period Interaction. This term measures whether or not the difference between the companies is the same in each period. Equally, it measures if the difference between periods is the same for each company. When the interaction is statistically significant there is little interest in the main effects. In this case averages over one of the factors ignore important variations.

Figure 5.5a *Frequency distribution - Number of work assignments per pilot per period on the Inner Route - Company A*

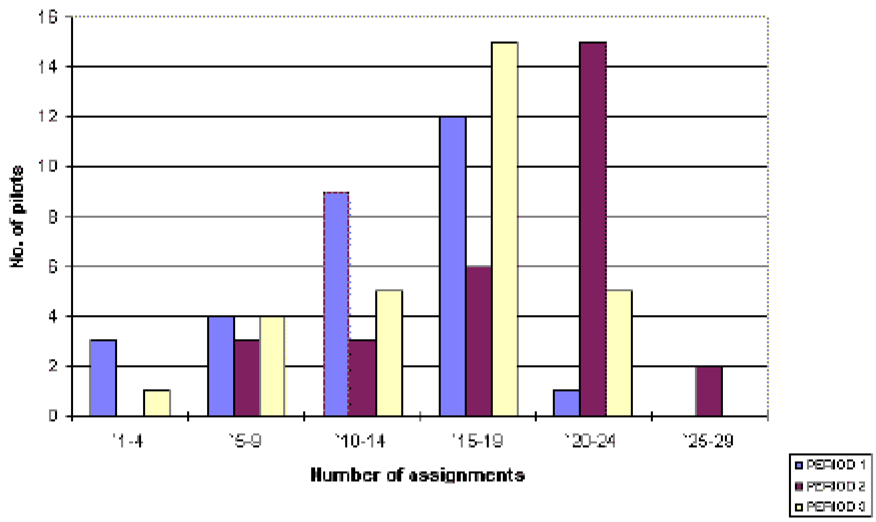
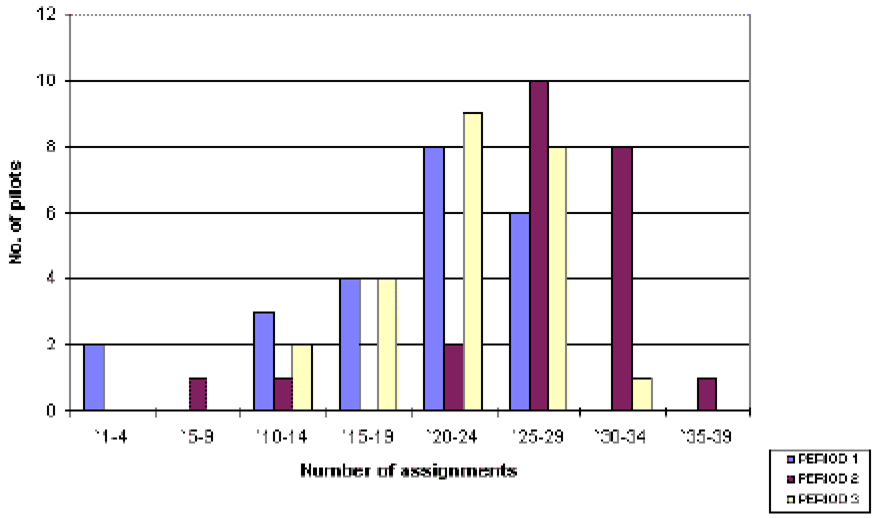


Figure 5.5b *Frequency distribution - Number of work assignments per pilot per period on the Inner Route - Company B*



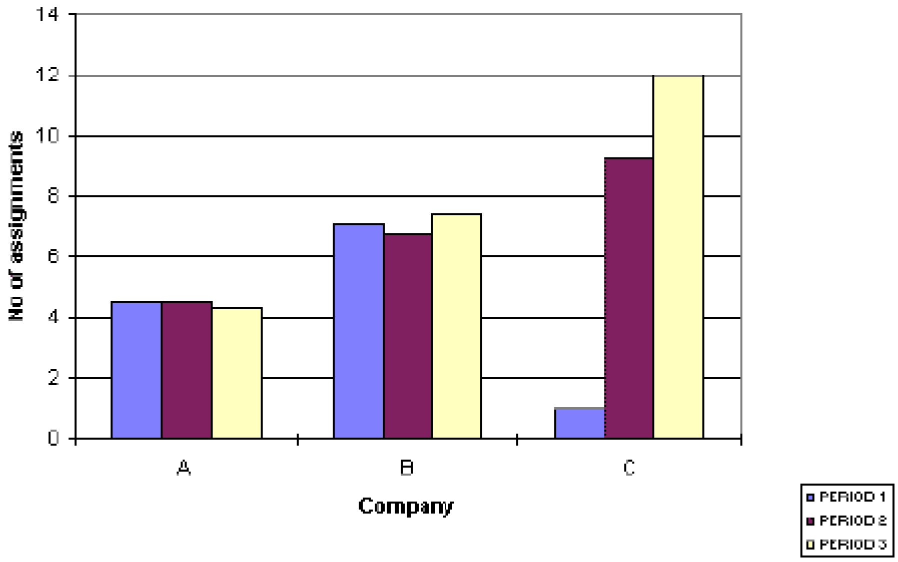
5.4 Number of Work Assignments per Pilot - Hydrographers Passage

Hydrographers Passage is a region of compulsory pilotage which extends east from Mackay and involves 10 – 14 hours of pilotage duties with the pilot required on the bridge for most of this time. For each of the companies across the three time periods, the mean number of work assignments per pilot are shown in Figure 5.6. Immediately noticeable from the figure is the small number of work assignments performed by Company C during the first time period. This result reflects the establishment of this company during this period.

Table 5.3 shows the between company and time period differences in the number of work assignments performed on Hydrographers passage per pilot. Inter-company differences related to the significantly fewer work assignments performed per pilot on this route by Company A (4.7) compared with Companies B (7.08) and C (7.44). A clear distinction of whether differences between Companies B and C existed was not shown by the post hoc analysis, possibly due to the sample size and variance associated with Company C's data. Given that Hydrographers Passage is the only operational region for Company C, it was expected that pilots from this company would perform a substantial proportion of the work on this route.

Examination of changes across time indicated that there were no significant differences in the number of work assignments performed on Hydrographers passage across the 18 months (Table 5.3). This finding applied to each of the companies.

Figure 5.6 *Mean number of work assignments per pilot on the Hydrographers Passage by Company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 5.3 *Analysis of the mean number of work assignments per pilot on the Hydrographers Passage (1 Jan 1996 - 30 June 1997) (1)*

Effect	**Post hoc results (2)**	**Mean (sem)**	**F Statistics**	**p-value**
Company (main effect)			5.3	0.0061
A	1	4.78 (0.644)		
B	2	7.08 (0.583)		
C	1/2	7.44 (1.804)		
Period (main effect)			0.25	0.7790
1	n/a	4.19 (1.288)		
2	n/a	6.87 (1.081)		
3	n/a	7.95 (1.088)		
Company * Period interaction			1.46	0.2176

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.

2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01) n/a Post hoc testing not performed when main effects not significant.

Company (Main Effect). This term measures whether or not there is a difference between companies averaged across the three time periods.

Period (Main Effect). This term measures whether or not there is a difference between the periods averaged across the companies.

Company * Period Interaction. This term measures whether or not the difference between the companies is the same in each period. Equally, it measures if the difference between periods is the same for each company. When the interaction is statistically significant there is little interest in the main effects. In this case averages over one of the factors ignore important variations.

Figure 5.7a *Frequency distribution - Number of work assignments per pilot per period on the Hydrographers Passage - Company A*

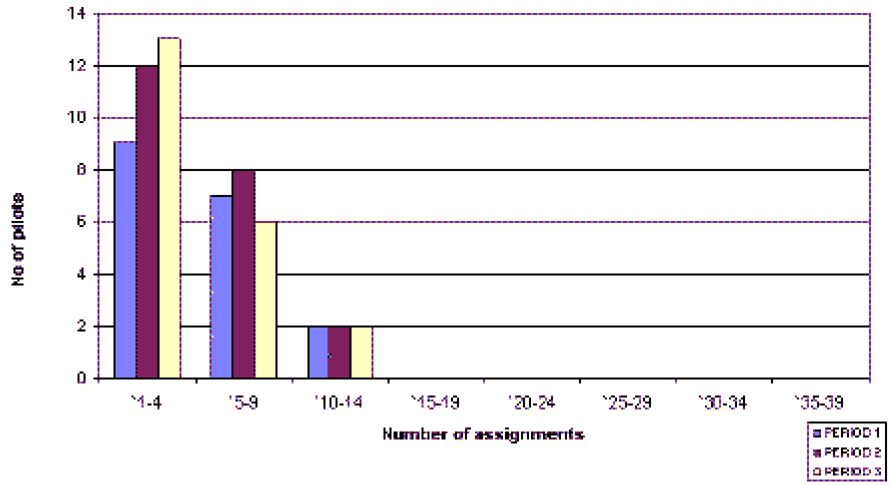


Figure 5.7b *Frequency distribution - Number of work assignments per pilot per period on the Hydrographers Passage - Company B*

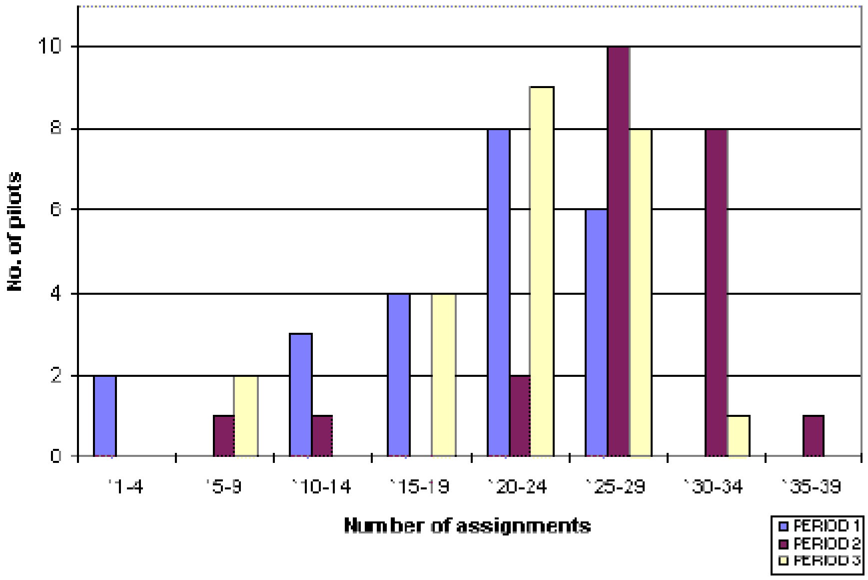
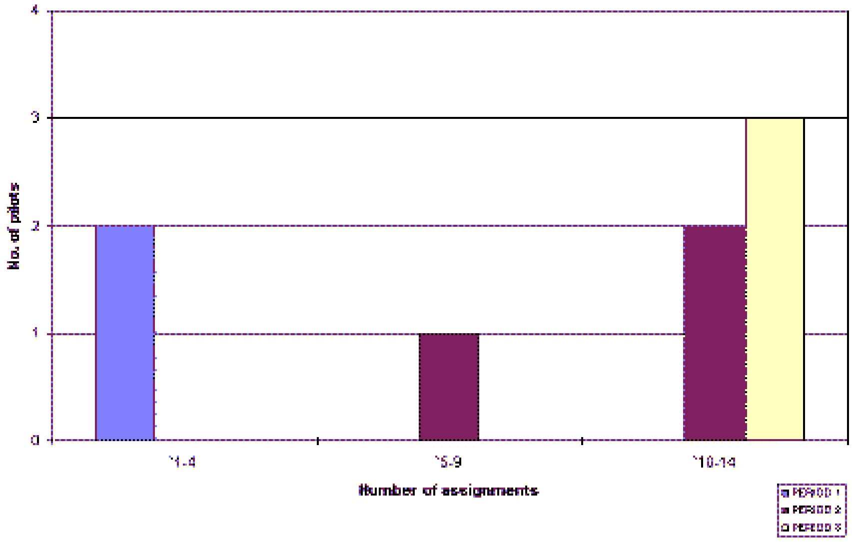


Figure 5.7c *Frequency distribution - Number of work assignments per pilot per period on the Hydrographers Passage - Company C*

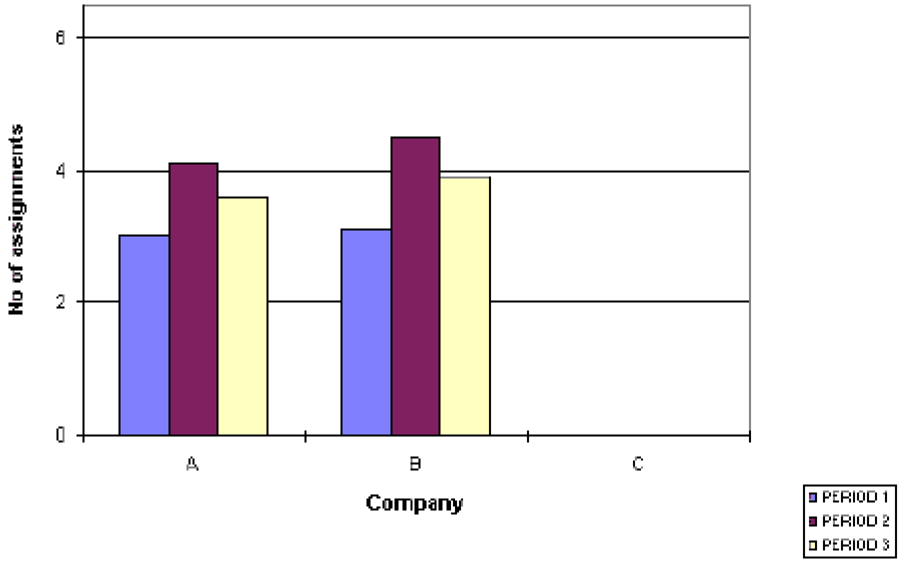


5.5 Number of Work Assignments per Pilot - Great North East Channel

The Great North East Channel is a shipping route extending north east from Cape York. It is not an area of compulsory pilotage however, the Australian Maritime Safety Authority and the International Maritime Organisation recommend the services of local marine pilots be used when transiting this region (Australian Reef Pilots Ltd. 1996). Company C does not operate on this shipping route and therefore, was not included in the following analysis.

Figure 5.8 displays the mean number of assignments per pilot performed on the Great North East Channel, for Companies A and B across the time periods. Table 5.4 summarises the analysis of this data in terms of company and period differences. No significant differences between companies or over the three 6 month periods existed. This finding suggests that work on this shipping route was fairly evenly distributed between Companies A and B and did not change substantially over the 18 month analysis period.

Figure 5.8 *Mean number of work assignments per pilot on the Great North East Channel by company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 5.4 *Analysis of the mean number of work assignments per pilot on the Great North East Channel (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			0.47	0.4965
A	1	3.61 (0.292)		
B	1	3.83 (0.385		
C	n/a	n/a		
Period (main effect)			2.07	0.1310
1	n/a	3.06 (0.454)		
2	n/a	4.30 (0.422)		

3	n/a	3.81 (0.378)		
Company * Period interaction			0.03	0.972

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01) n/a Post hoc testing not performed when main effects not significant.

Company (Main Effect). This term measures whether or not there is a difference between companies averaged across the three time periods.

Period (Main Effect). This term measures whether or not there is a difference between the periods averaged across the companies.

Company * Period Interaction. This term measures whether or not the difference between the companies is the same in each period. Equally, it measures if the difference between periods is the same for each company. When the interaction is statistically significant there is little interest in the main effects. In this case averages over one of the factors ignore important variations.

5.6 Duration of Work Assignments

Based on the work schedule files, the duration of work assignments, that is, the time on board ship, extended from the time of embarkation to disembarkation. However, following consultation with the Pilot Advisory Group members, it was determined that travel to and from the ship should be classified as work. Hence, as part of the analysis, work assignment duration was adjusted for travel. The results revealed a significant travel effect, indicating the inclusion of travel significantly ($p < 0.0001$) increased the duration of work assignments.

Figure 5.9 shows the duration of work assignments (ship time) in the three 6-month periods for each company separately. Table 5.5 summarises the analysis of assignment duration in terms of company and period differences. Significant company differences in work assignment duration were evident, with pilots from Company A working significantly longer assignments (45.6 hours) than pilots from Company B (40.8 hours) and Company C (13.9 hours).

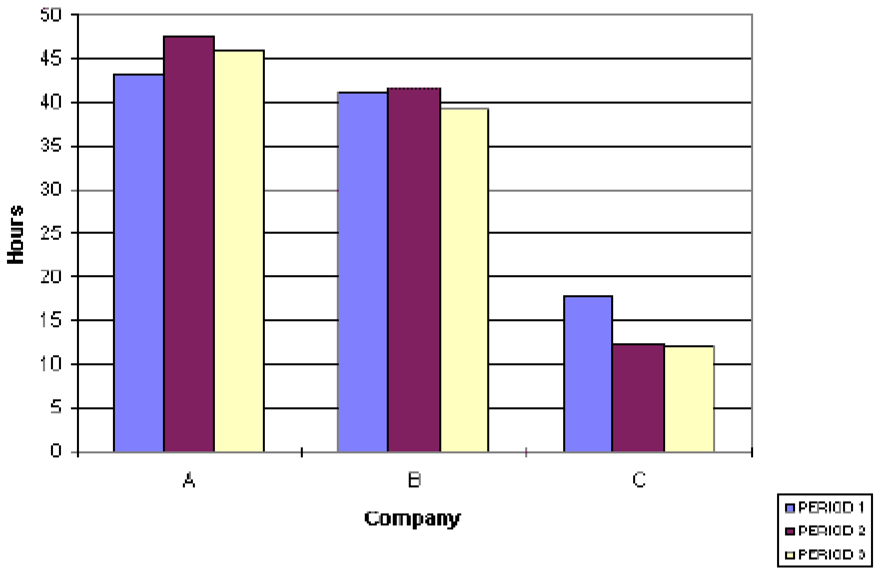
While the substantially shorter duration of work assignments performed by Company C was expected due to the short transit time through Hydrographers Passage, the significant differences between Companies A and B is more perplexing. Both these companies operate in the same regions and therefore, it was anticipated that work assignments would be of similar duration. However, it is possible that the longer assignments of Company A may relate to personnel embarking on ships some days before entering the compulsory pilotage region (e.g. Brisbane) and then travelling on the ship without officially performing pilotage duties until the compulsory region. This practice may carry its own risk for fatigue potential, as the alternative living conditions experienced on board may not always be conducive to optimising sleep or alertness. Additionally, during busy periods this practice may not represent the most efficient use of a limited workforce.

When the average duration of work assignments of Great Barrier Reef pilots is compared to other groups of marine pilots, some of the unique features of pilotage in the Great Barrier Reef - Torres Strait region are highlighted. Long haul pilotage trips performed by pilots from the United Kingdom involve approximately 5.5 hours of navigating vessels (Shipley, 1978), while a typical pilotage assignment undertaken by Port Phillip sea pilots involves around 10 to 12 hours of pilotage work (Berger, 1984). Hence, it is apparent that the work assignments of Great Barrier Reef pilots are longer in duration than for either of the two comparison groups. This is especially true for pilots working for Companies A and B. The differences in the size of the area serviced by the pilot groups would seem to be one of the principle reasons attributable to this finding. Nevertheless, it is important to consider the possible effects of prolonged duty times on pilots. It could be anticipated that Great Barrier Reef pilots may be susceptible to greater levels of fatigue, as a direct consequence of the longer work assignments. It should be noted however, that work assignment times presented here only indicate the time between embarkation and disembarkation and do not differentiate between time working on the bridge and time spent resting. On tour log books will specifically detail bridge time and sleep periods per work assignments.

By presenting the duration of work assignments per six month period as frequency distributions (Figure 5.10a, and Figure 5.10b), some insight into the average figures reported above (Table 5.5) is obtained. Figure 5.10a clearly shows that several work assignments undertaken by Company A extended beyond a one week duration. In contrast, no assignments performed by Company B fell into this category (Figure 5.10b). This trend within the data most likely contributes to the longer average assignment duration reported for Company A. Although not shown, the short transit time through Hydrographers Passage resulted in all work assignments for Company C being less than 24 hours.

With regards to work assignment duration across time, no significant differences were observed. This temporal pattern was stable for all of the pilot companies (Table 5.5).

Figure 5.9 *Mean duration (hours) of work assignments (ship time) by Company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 5.5 *Analysis of the mean duration (hours) of work assignments (ship time) (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			53.36	0.0001
A	1	45.6 (0.648)		
B	2	40.8 (0.60)		
C	3	13.92 (7.128)		
Period (main effect)			2.55	0.0781
1	n/a	34.08 (6.744)		
2	n/a	34.84 (1.848)		
3	n/a	32.40 (1.656)		
Company * Period interaction			1.06	0.3738

1. (1) Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.

2. (2) Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01) n/a Post hoc testing not performed when no significant man effects.

Company (Main Effect). This term measures whether or not there is a difference between companies averaged across the three time periods.

Period (Main Effect). This term measures whether or not there is a difference between the periods averaged across the companies.

Company * Period Interaction. This term measures whether or not the difference between the companies is the same in each period. Equally, it measures if the difference between periods is the same for each company. When the interaction is statistically significant there is little interest in the main effects. In this case averages over one of the factors ignore important variations.

Figure 5.10a *Frequency distribution - Duration (hours) of work assignments (ship time) per period - Company A*

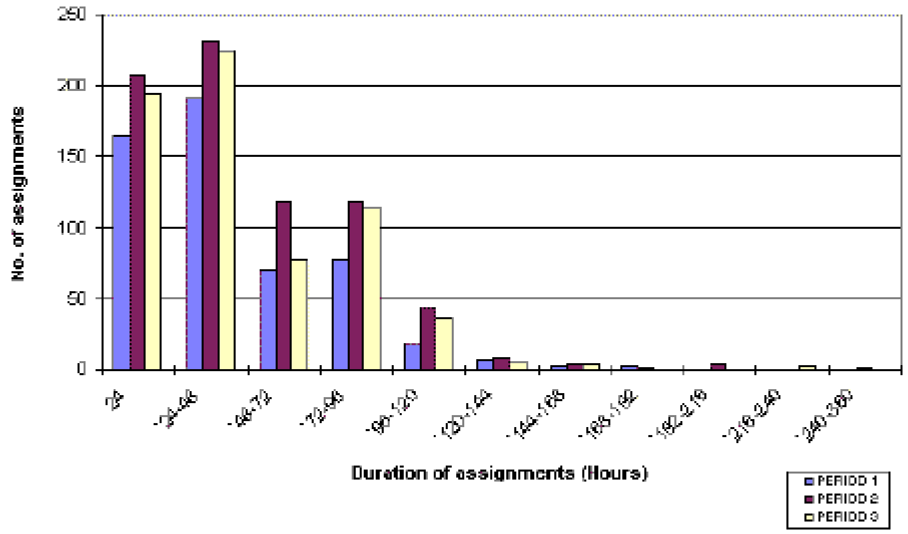
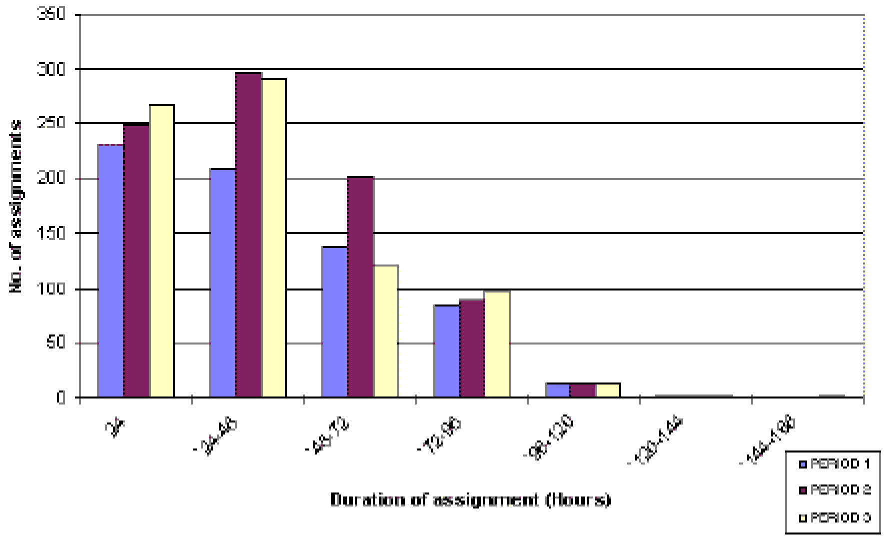


Figure 5.10b *Frequency distribution - Duration (hours) of work assignments (ship time) per period - Company B*



5.7 Duration of Breaks between Work Assignments

Breaks between work assignments potentially represent a period of time during which pilots can recuperate from a work assignment and prepare themselves for their next voyage. For pilots who reside in the operational region (Northern and Central Queensland), breaks may be spent at home. However, in many situations breaks are spent in alternative accommodation such as hotels, motels and/or pilot houses.

Within the present work schedule files, breaks between work assignments were determined from the date and time of disembarkation to the date and time of the next embarkation (non-ship time). Travel to and from ships significantly decreased ($p < 0.0001$) the duration of breaks between assignments and hence, breaks were travel adjusted. In some circumstances, travel between ports may also be undertaken during assignment breaks, which in turn would further reduce break duration.

In an attempt to ensure that pilots receive adequate time to recover between work assignments, the Australian Maritime Safety Authority have established regulations stipulating minimum rest breaks between consecutive pilotage assignments performed in the Great Barrier Reef - Torres Strait region. These regulations state that prior to any work assignment, a minium of 12 consecutive hours of rest, excluding travel must be taken by the pilot, except for 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).

Figure 5.11 illustrates the average duration of assignment breaks in the three time periods for each company separately. A summary of the analysis of this data in terms of company and period differences is shown in Table 5.6. There were significant differences between the companies, with pilots from Company A recording breaks of 52.8 hours, pilots from Company B recording breaks of 48.9 hours and pilots from Company C recording breaks of

72.0 hours. These results seem to suggest that all of the Companies are complying with the minimum break duration regulations stipulated by the Australian Maritime Safety Authority.

Mean data however, fails to highlight the variability which exists within any data set and hence, to assess variability, the duration of breaks between work assignments have been presented as frequency distributions (Figures 5.12a, Figures 5.12b and Figure 5.12c). From these figures, it can be identified that in the majority of situations, rest breaks do conform with the Australian Maritime Safety Authority regulations. Most work assignments are interspersed by at least 24 hours of non-work time, thereby more than adequately meeting the 12 and 24 hour minimum time periods state in the regulations. However, it is also evident on the distributions of Companies A and B that there were a number of times when breaks between work assignments failed to comply with regulations. While extenuating circumstances may have existed, that less than 12 hours rest between work periods was obtained on some occasions is somewhat disconcerting.

A recent investigation revealed that during work assignments, both quantity and quality of sleep achieved by Great Barrier Reef pilots tends to be compromised. For instance, thirty-one percent of Great Barrier Reef pilots attain an average of less than 4 hours sleep per 24 hours while working, while 55 percent rated their sleep as fair, poor or very poor in quality (Parker et al. 1997). When these findings are viewed in combination with the results of studies investigating the effects of restricted sleep on mood and performance, a highly undesirable picture emerges. Restricted sleep has been shown to cause significant reductions in cognitive, vigilance and memory performance and increased levels of fatigue (Dinges et al. 1997; Tilley & Wilkinson 1984; TSB 1997; Wittersheim et al. 1992). Additionally, it seems that at least 2 nights of recovery sleep are required following a period of sleep restriction, before complete recovery is achieved (Dinges et al. 1997; Morris & Miller 1996; TSB 1997; Wittersheim et al. 1992). These findings place doubt over the current regulations stipulating minimum rest breaks of 12 and 24 hours (AMSA 1997) as even with 24 hours rest between work assignments, the opportunity to achieve 2 nights of recovery sleep is not available. Furthermore, that in certain situations Great Barrier Reef pilots are only achieving 12 or less hours recovery time between work assignments suggests there may be a heightened risk of performance impairment and/or fatigue development. Accordingly, a review of the current regulations and future monitoring of rest break duration may be warranted.

At no time during the 18 month analysis period did the rest breaks experienced by Company C fail to meet current regulations (Figure 5.12c).

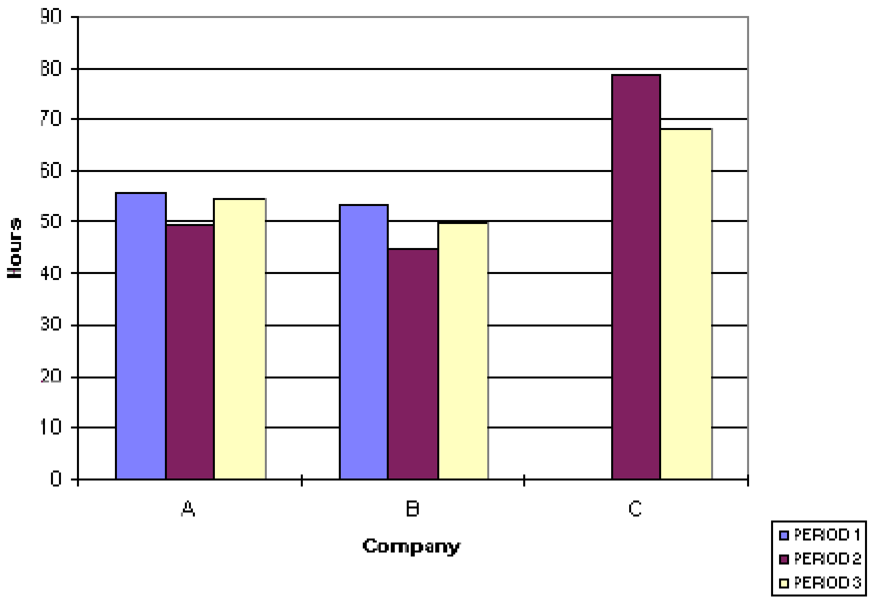
By considering average assignment and break duration together (Table 5.5 and Table 5.6), an approximation of the work (ship time) to rest (non-ship time) ratio for each of the pilot companies was calculated. Both Companies A and B recorded work to rest ratios of around 1 : 1.2, whereas Company C recorded a ratio of 1 : 5.2. Thus, relative to work assignment duration Company C personnel experience much longer periods of time off between assignments compared with either of the other two pilot groups.

That both Companies A and B recorded the same work to rest ratio highlights the similarity between the two groups in terms of pilotage operations. Based on results so far, it would appear that Company B personnel perform more assignments of shorter duration with shorter rest breaks, whereas Company A pilots perform fewer but longer work assignments with longer rest breaks. A point of interest may be whether a greater number of shorter assignments with shorter breaks is more fatiguing than fewer longer assignments with longer breaks. That is, whether more frequent travel associated with a greater number of shorter assignments is more fatiguing than exposure to the on-ship environment for longer periods.

Comparisons of the work to rest ratios of Great Barrier Reef pilots with the work to rest ratios of other groups of marine pilots reveal some interesting findings. For instance, the work to rest ratio calculated from data on long haul pilots from the United Kingdom (Shipley 1978) was approximately 1 : 9.25. Thus, the rest periods relative to work periods were more than six times longer for the pilots from the United Kingdom, compared with Great Barrier Reef pilots working for Companies A and B. These findings need to be interpreted cautiously as distinct differences between the two pilotage groups exist in terms of the size of the region serviced, work assignment duration and work roster systems. However, the much shorter period of rest experienced by the majority of Great Barrier Reef pilots seems to support the previous suggestion that Great Barrier Reef pilots may have an increased susceptibility to experiencing fatigue as a consequence of their work conditions, as compared to some other groups of marine pilots.

With regards to changes across time it was evident that the duration of breaks between work assignments was significantly shorter during the second time period as compared to the first and third periods. This finding is consistent with the increased work availability reported during this middle 6 month period.

Figure 5.11 *Mean duration of breaks (hours) between work assignments (non-ship time) by Company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 5.6 *Analysis of the duration of breaks (hours) between work assignments (non-ship time) (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			16.19	0.0001
A	1	52.84 (0.755)		
B	2	48.85 (0.658)		
C	3	72.00 (7.754)		
Period (main effect)			19.55	0.0001
1	1	54.30 (1.000)		
2	2	47.12 (0.763)		
3	1	52.15 (0.853)		
Company * Period interaction			1.09	0.350

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01).

Company (Main Effect). This term measures whether or not there is a difference between companies averaged across the three time periods.

Period (Main Effect). This term measures whether or not there is a difference between the periods averaged across the companies.

Company * Period Interaction. This term measures whether or not the difference between the companies is the same in each period. Equally, it measures if the difference between periods is the same for each company. When the interaction is statistically significant there is little interest in the main effects. In this case averages over one of the factors ignore important variations.

Figure 5.12a *Frequency distribution - Duration of breaks between work assignments (non-ship time) per period - Company A*

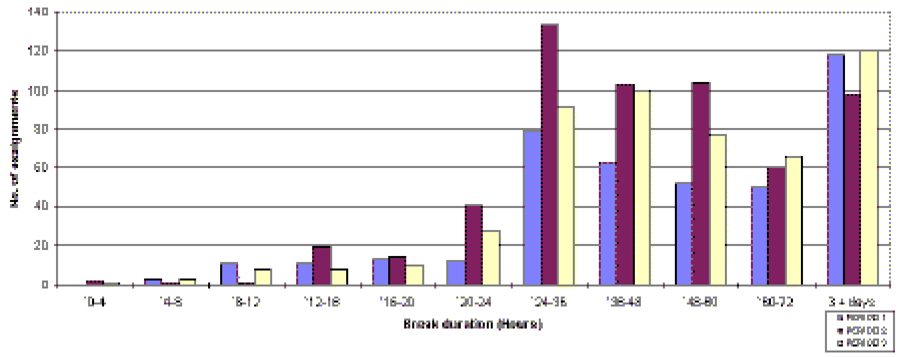


Figure 5.12b *Frequency distribution - Duration of breaks between work assignments (non-ship time) per period - Company B*

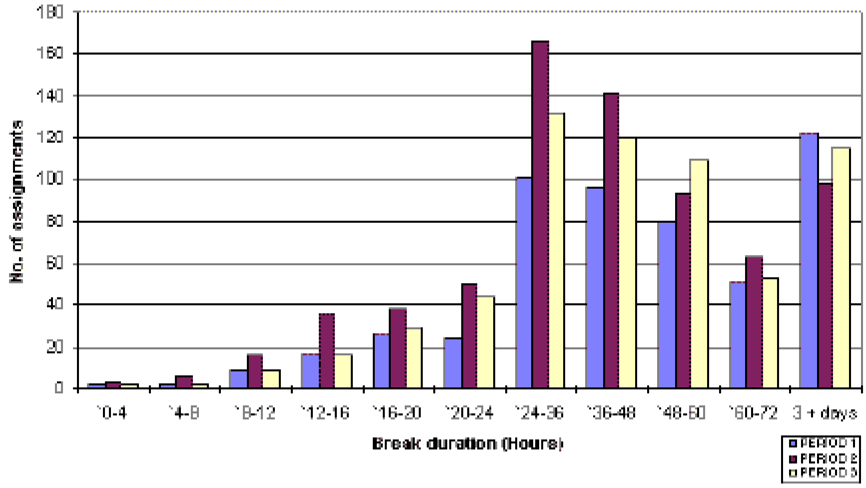
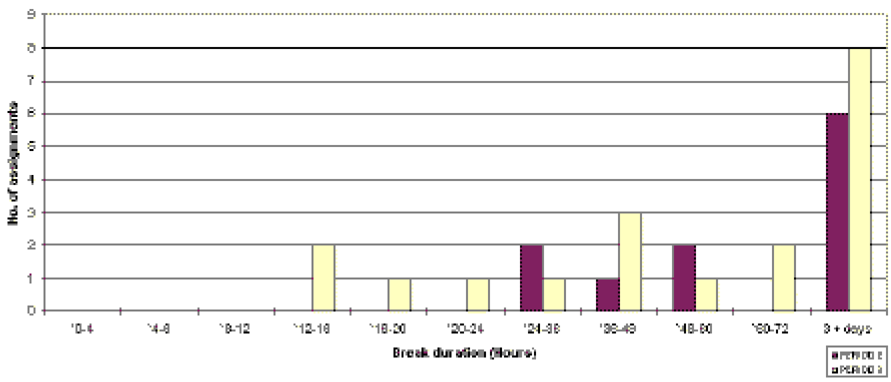


Figure 5.12c *Frequency distribution - Duration of breaks between work assignments (non-ship time) per period - Company C*



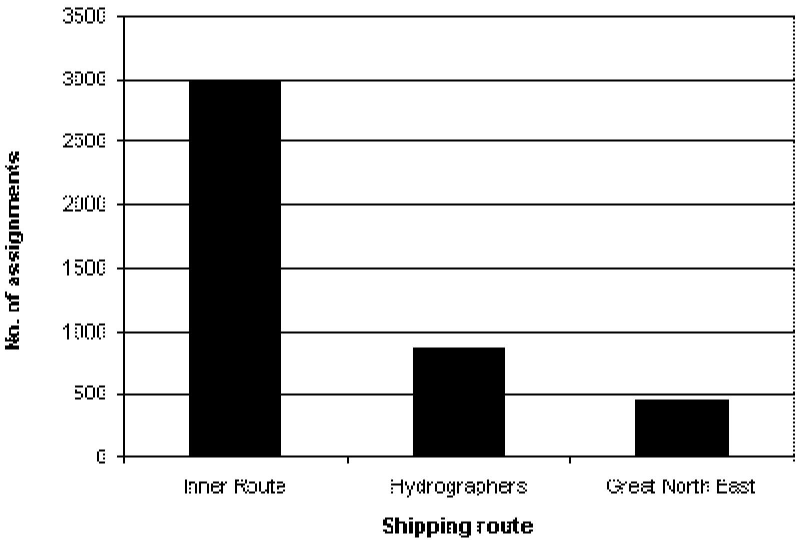
6.0 Results and discussion

Within the Great Barrier Reef – Torres Strait region, there are three main shipping routes transited by pilots. Hydrographers Passage is located east of Mackay, the Inner Route runs parallel to the Queensland coastline while the Great North East Channel extends north east from Cape York. The characteristics of each route vary considerably in terms of transit times, navigational hazards and travel requirements. Hence, as part of the overall fatigue focus of the study, it was deemed important to assess the potential fatigue aspects associated with the main shipping routes transited by Great Barrier Reef pilots.

6.1 Number of work assignments

Figure 6.0 shows the mean number of assignments for each of the shipping routes. Across the 18 month period, 2987 Inner Route, 862 Hydrographers Passage and 445 Great North East Channel assignments were performed. Comparisons made on the basis of the Poisson model indicated significant between route differences existed ($p < 0.01$). Based on mean figures, it is evident that approximately 70, 20 and 10 percent of pilotage work performed in the Great Barrier Reef – Torres Strait region was conducted on the Inner Route, Hydrographers Passage and the Great North East Channel respectively. Hence, Inner Route assignments constitute the main source of work for Great Barrier Reef pilots.

Figure 6.0 *Mean number of work assignments, by shipping route*



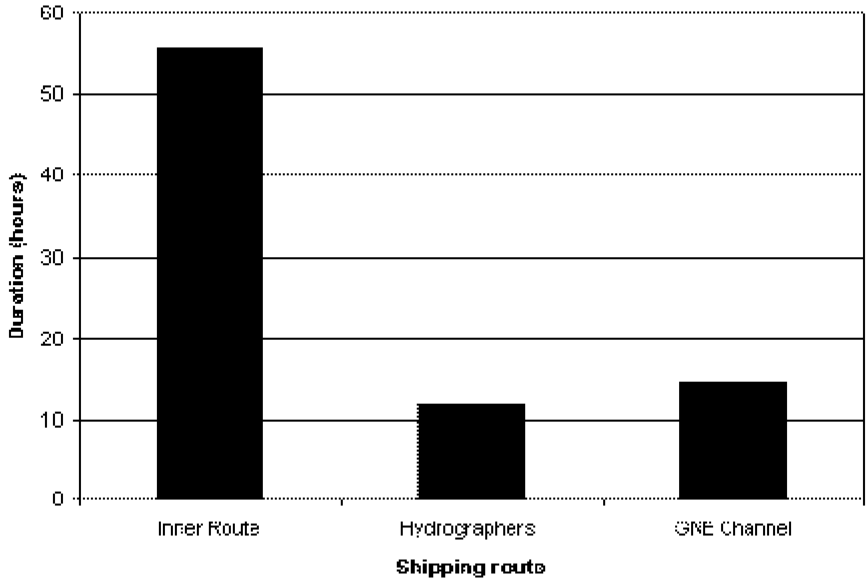
95% Confidence intervals for each route were:

Inner Route: 2880-3094; Hydrographers: 804.5-919.5; Great North East: 403.6-486.3

6.2 Duration of work assignments

Figure 6.1 presents the mean duration of work assignments (ship time) for each of the shipping routes while Table 6.0 summarises the analysis of shipping route differences in this data. Assignments on the Inner Route were significantly longer (55.65 hours) compared with assignments on Hydrographers Passage (12.08 hours) and the Great North East Channel (14.64 hours), which were similar. Although not shown, frequency distributions seemed to confirm these results as over 95% of Inner Route assignments were longer than 30 hours in duration, approximately 95% of Hydrographers Passage assignments were between 10 and 15 hours duration and approximately 90% of Great North East Channel voyages were between 9 and 20 hours in duration. These findings reflect the transit distances associated with each route. As a consequence of the differences in average assignment duration between shipping routes, it would seem important to consider the differences between shipping routes when assessing and managing potential fatigue.

Figure 6.1 *Mean duration (hours) of work assignments (ship time) by shipping route*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 6.0 *Analysis of the mean duration (hours) of work assignments (ship time) by shipping route (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
			5.1	0.0001
Inner Route	1	55.65 (0.39)		
Hydrographers Passage	2	12.08 (0.72)		
Great North East Channel	2	14.64 (1.0)		

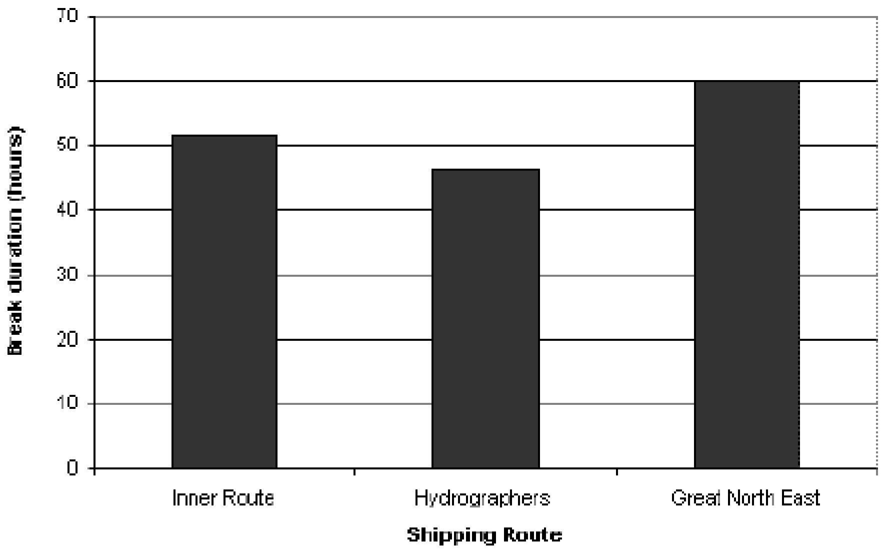
1. Results of full two-way analysis of variance (ANOVA) model. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01).

6.3 Duration of breaks between work assignments

Figure 6.2 shows the mean duration of breaks between assignments (non-ship time) by shipping route, while Table 6.1 presents a summary of the analysis of this data in terms of shipping route differences. Breaks between voyages on Hydrographers Passage were significantly shorter (46.32 hours) compared with assignments on the Inner Route (51.6 hours) and Great North East Channel (53.04 hours).

When presenting this data in frequency distribution format (Figure 6.3), it can be noted that for all three shipping routes, the majority of assignments were interspersed by breaks of 24 hours or more. Thus, current minimum rest break regulations are being met in most instances. However, a small percentage of rest breaks failed to meet regulations which state a minimum of 24 hours rest before Inner Route passages and 12 hours for Hydrographers Passage and Great North East Channel voyages. In light of the heightened fatigue potential associated with inadequate rest between work periods, closer monitoring of rest breaks may be warranted.

Figure 6.2 *Mean duration (hours) of breaks between work assignments (non-ship time) by shipping route*



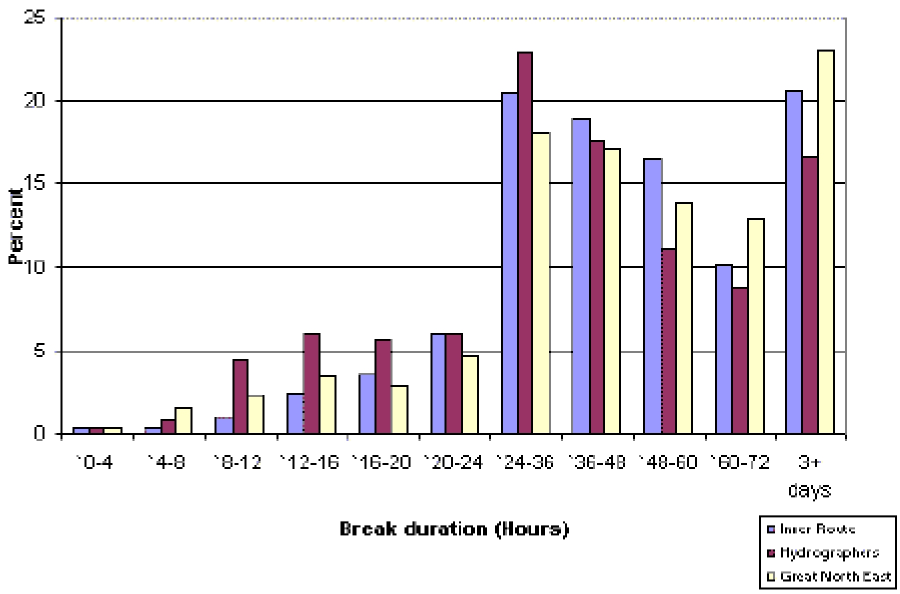
Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 6.1 *Analysis of the mean duration (hours) of breaks between work assignments (non-ship time) by shipping route (1)*

Effect	Post hoc results (2)	Mean + (sem)	F Statistics	p-value
			10.10	.0001
Inner Route	1	51.6 (0.06)		
Hydrographers Passage	2	46.32 (1.13		
Great North East Channel	1	53.04 (1.49)		

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 I Experimental Error Rate = .01).

Figure 6.3 *Frequency distribution - Duration of breaks between work assignments by shipping route*



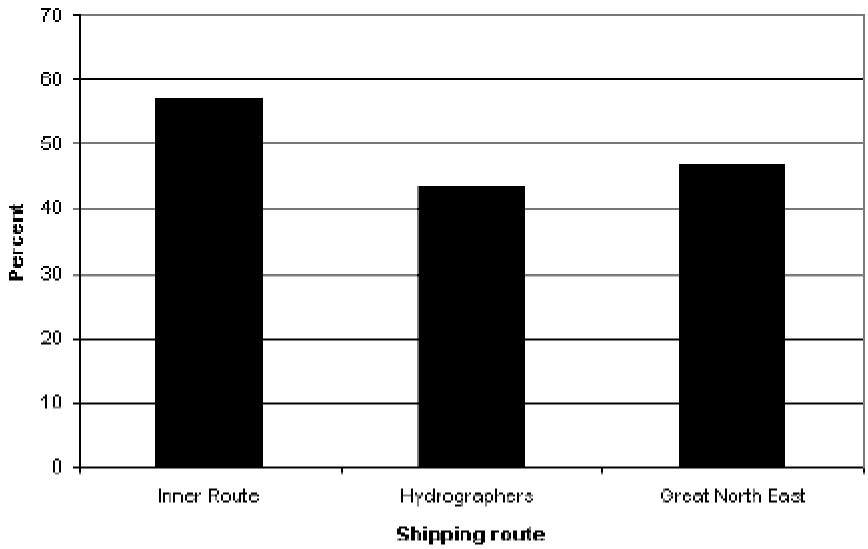
6.4 Percent of the work assignment performed at night

Given the additional demands associated with night work (refer to section 5.11) an assessment of the percent of assignment time (ship time) undertaken at night (defined as between 1818 and 0525 hours) on each shipping route was conducted. Figure 6.4 shows this data for each shipping route separately, while Table 6.2 presents a summary of the analysis of shipping route differences in this data. There were significant differences between each of the shipping routes, with a greater percentage of Inner Route assignments being performed at night (57.33%), followed by assignments on the Great North East Channel (47.0%) and then assignments on Hydrographers Passage (43.6%). This pattern in the results may be related to the transit time associated with each route as the longer the work assignment is, the greater the probability that night work will be incurred. Figure 6.5 clearly shows that the majority of Inner Route assignments involved between 40 and 70% of night work.

That Inner Route assignments are significantly longer in duration (Table 6.0) and involve greater amounts of night work (Table 6.2) indicates that there may be a heightened risk of fatigue development associated with this route. The potential importance of this finding is enhanced when viewed in combination with the fact that Inner Route assignments constitute the main source of pilotage work in the Great Barrier Reef – Torres Strait region (Figure 6.0).

To optimise the potential for sleep at sea, the possibility of charting alternative shipping channels should be examined. For example, pilots have commented that the use of the Fairway Channel region of the Inner Route would eliminate one of the most difficult sections of this route and permit more extensive rest and sleep periods (Personal Communication – Pilot Advisory Group, 18 May 1998). At present, the channel has been surveyed but no charts or Differential Global Position (DGP) facilities for this region have been developed.

Figure 6.4 *Percent of assignment (ship time) performed at night by shipping route*



Note: Data analysis based on n values shown in Methods (Section 3.2).

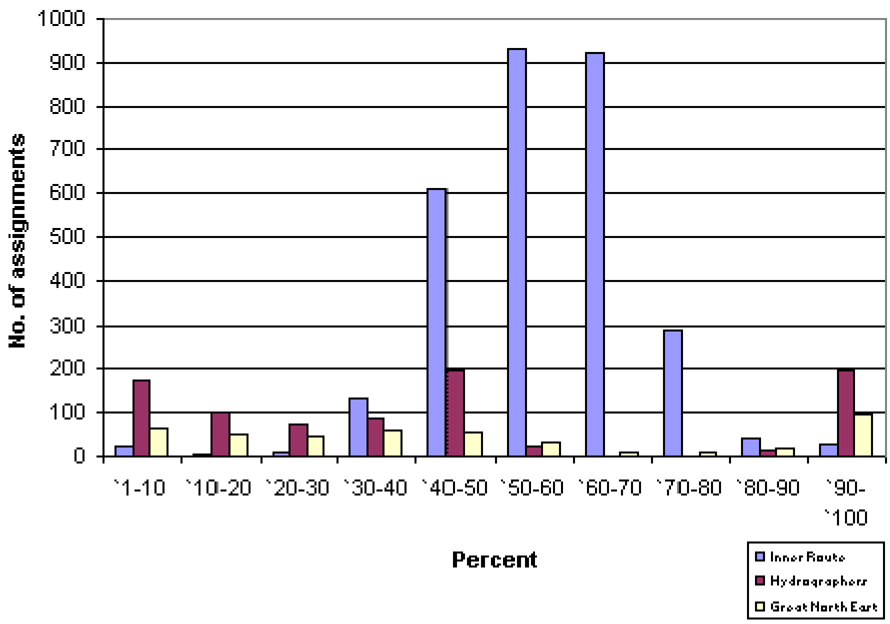
Table 6.2 *Analysis of the mean percent of assignments (ship time) performed at night, by shipping route (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value

			158.38	0.0001
Inner Route	1	57.33 (0.394)		
Hydrographers Passage	2	43.60 (0.734)		
Great North East Channel	3	47.00 (1.022)		

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 I Experimental Error Rate = .01).

Figure 6.5 *Frequency distribution - Percent of assignment (ship time) performed at night by shipping route*

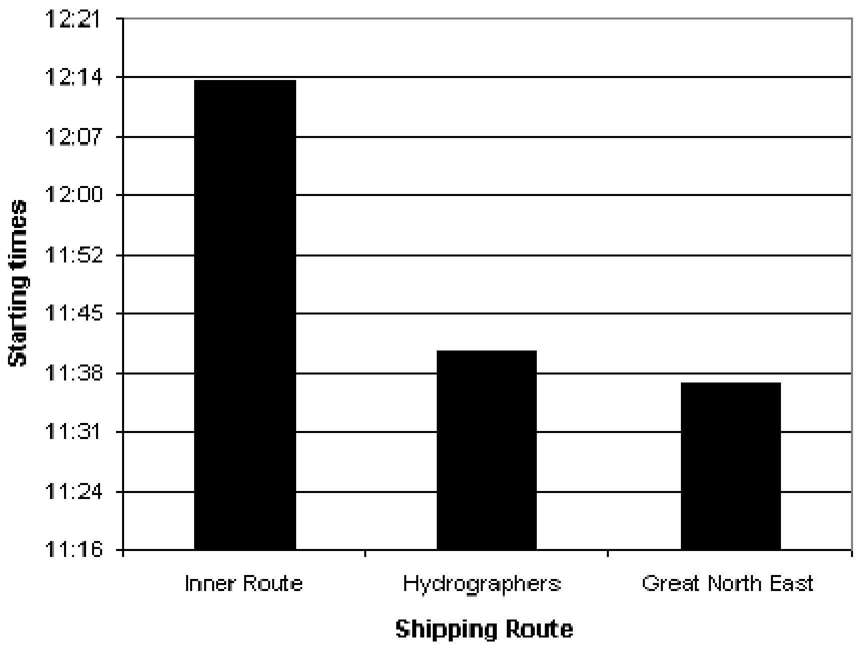


6.5 Starting times of work assignments

Figure 6.6 shows the mean starting times of work assignments conducted on each shipping route. A summary of the analysis of shipping route differences in this data is presented in Table 6.3. While significant differences between the shipping routes in mean starting times of assignments existed, post hoc testing failed to identify the source of these differences. However, it can be noted from data within table 6.3 that Inner Route assignments (12:16) began approximately 45 to 50 minutes later than Hydrographers Passage (11:25) and Great North East Channel assignments (11:23).

As depicted by Figure 6.7, starting times were fairly evenly distributed over the 24 hour cycle, with around 15 to 20% of work assignments beginning in each 4 hour time period. As a consequence of this even distribution over the 24 hour cycle, when results are averaged a mean starting time of approximately 1200 hours was obtained.

Figure 6.6 *Mean starting times of work assignments by shipping route*



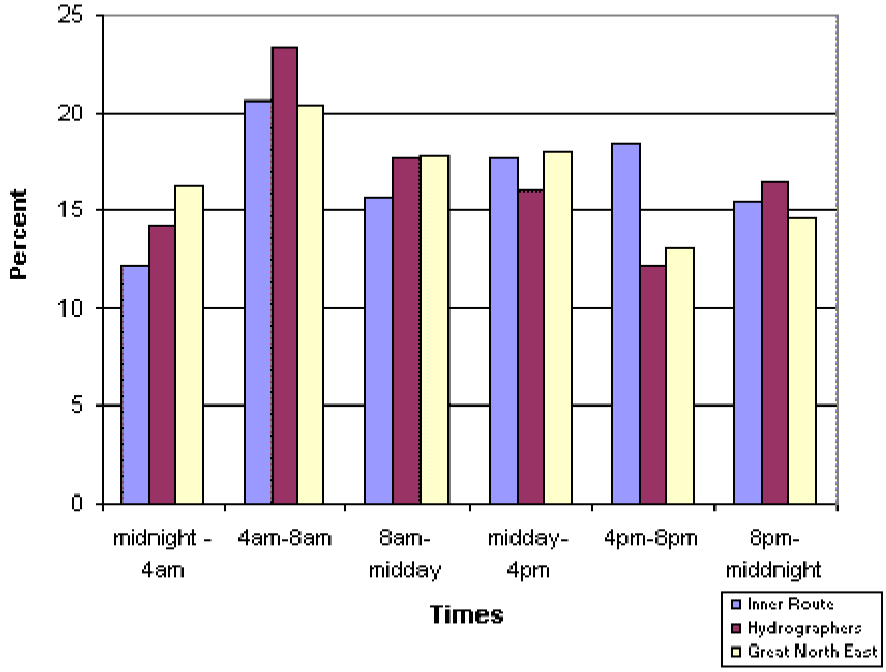
Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 6.3 *A summary of the analysis of the starting times of work assignments, by shipping route (1)*

Effect	Post hoc results (2)	Mean + (sem)	F Statistics	p-value
			5.72	0.0033
Inner Route	1	12:16 (19:10)		
Hydrographers Passage	1	11:25 (13:61)		
Great North East Channel	1	11:23 (18:94)		

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 I Experimental Error Rate = .01).

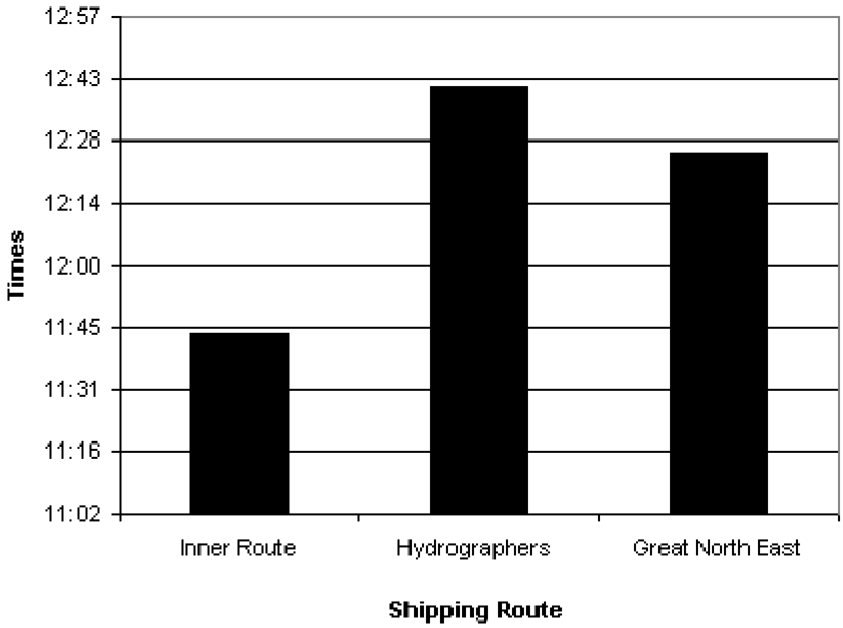
Figure 6.7 *Frequency distribution - Starting times of work assignments by shipping route*



6.6 Starting Times of Breaks between Work Assignments

The average starting times of rest breaks between work assignments (non-ship time) for each shipping route are presented in Figure 6.8, while Table 6.4 summarises the analysis of shipping route differences in this data. Mean starting times of rest breaks around 1200 hours were recorded for all three shipping routes. This is once again attributable to the fairly even distribution of the starting times for rest breaks across the 24 hour cycle as depicted by Figure 6.9.

Figure 6.8 *Mean starting times of breaks between work assignments by shipping route*



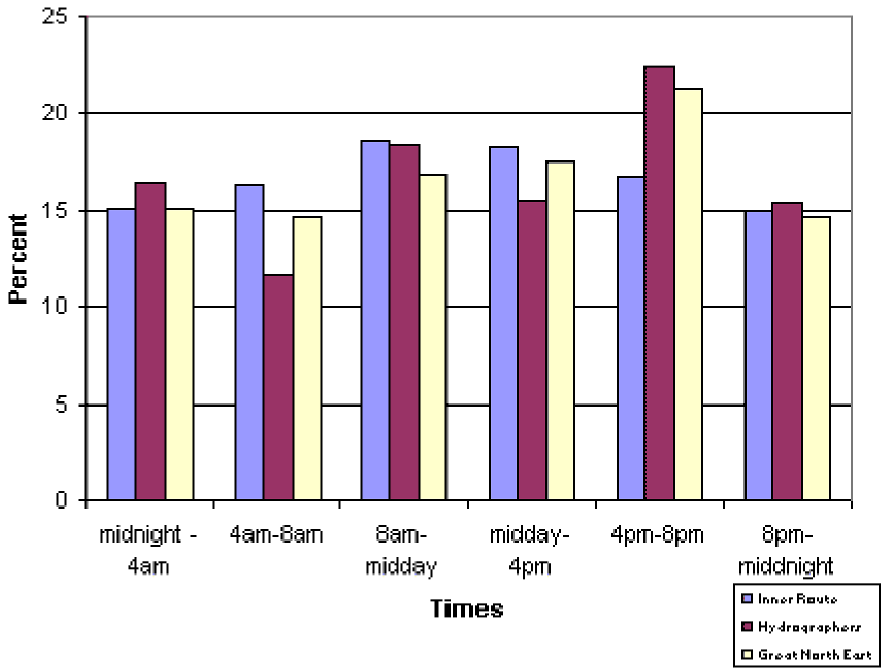
Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 6.4 *Analysis of the mean starting times of breaks between work assignments, by shipping route (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
			2.82	0.0599
Inner Route	n/a	11:51 (7:37)		
Hydrographers Passage	n/a	12:25 (13:72)		
Great North East Channel	n/a	12:16 (19:10)		

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 I Experimental Error Rate = .01) n/a Post hoc testing not performed when main effects not significant.

Figure 6.9 *Frequency distribution - Starting times of breaks between work assignments by shipping route*

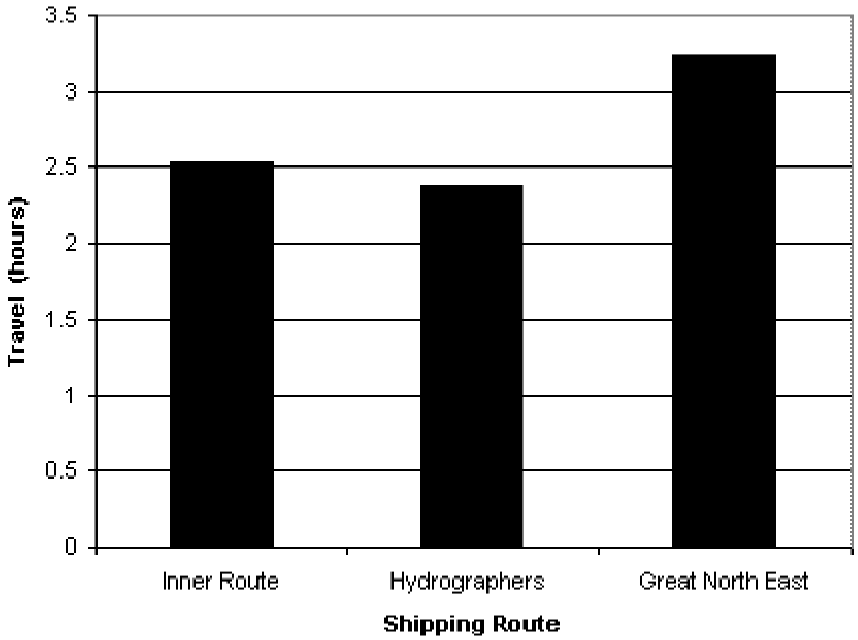


6.7 Travel To and From Ships Per Work Assignment

To determine whether any one particular shipping route may be associated with greater amounts of travel, an assessment of the travel duration to and from ships per work assignment for each shipping route was performed. Figure 6.10 presents this data for each shipping route separately, while Table 6.5 summarises the analysis of shipping route differences in this data. There were significant differences, with mean travel to and from assignments on the Great North East channel (3.24 hours) being greatest, followed by travel to and from Inner Route assignments (2.53 hours) and then travel to and from Hydrographers Passage assignments (2.38 hours). Figure 6.11 appears to confirm these results as while 100% of assignments on Hydrographers Passage and approximately 98% on the Inner Route involved 4 hours or less of travel, only 75% of assignments on the Great North East Channel had similar travel hours. The remaining 25% of Great North East Channel assignments involved between 4 and 8 hours of travelling to and from ships.

These results reflect the accessibility of boarding grounds associated with each route and the mode of transport used. For example, the remote location of boarding grounds for the Great North East Channel and the tendency to use launch vessels contributes to the longer duration of travel associated with this route. On the other hand, many of the boarding grounds for the Inner Route and Hydrographers Passage are located closer to shore, and in those instances when significant distances need to be travelled, helicopters are often used.

Figure 6.10 *Mean duration of travel to and from ships per work assignment by shipping route*



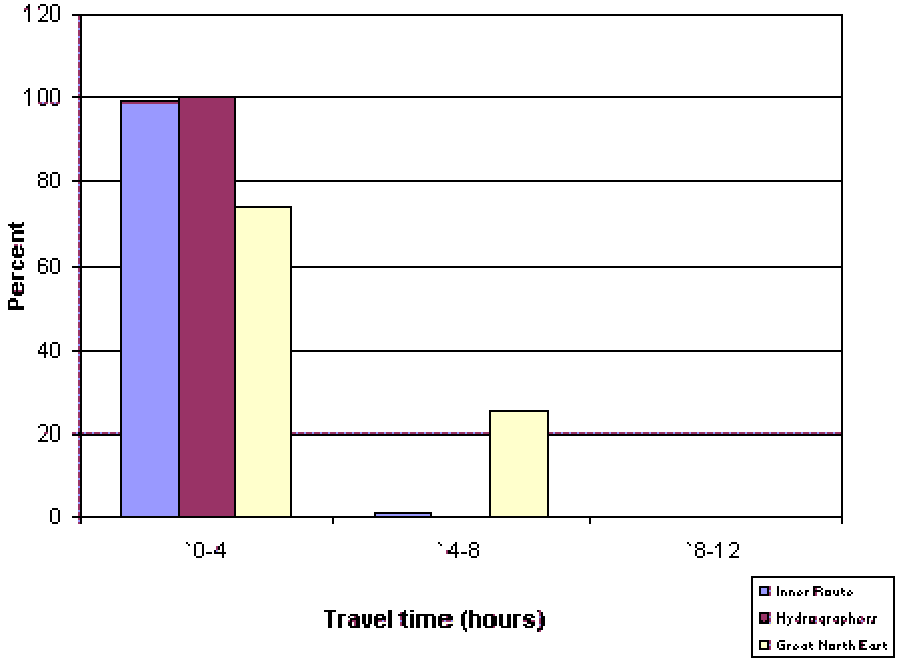
Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 6.5 *A summary of the analysis of the mean duration of travel to and from ships per work assignment by shipping route (1)*

Effect	**Post hoc results (2)**	**Mean (sem)**	**F Statistics**	**p-value**
			162.61	0.0001
Inner Route	1	2.53 (0.016)		
Hydrographers Passage	2	2.38 (0.029)		
Great North East Channel	3	3.24 (0.041)		

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 I Experimental Error Rate = .01).

Figure 6.11 *Frequency distribution - Duration of travel to and from ships per work assignment by shipping route.*



6.8 Number of potential sleep periods (2200-0800 hours) in breaks between work assignments

As noted earlier in the report, when sleep is taken between the hours of 2300 and 0700 the recuperative value of the recovery period tends to be greatest. To assess whether differences between shipping routes existed in terms of opportunity to achieve optimal sleep, an assessment of the number of times pilots were potentially able to obtain an uninterrupted period of sleep between 2200 and 0800 hours during rest breaks prior to assignments on each shipping route was undertaken.

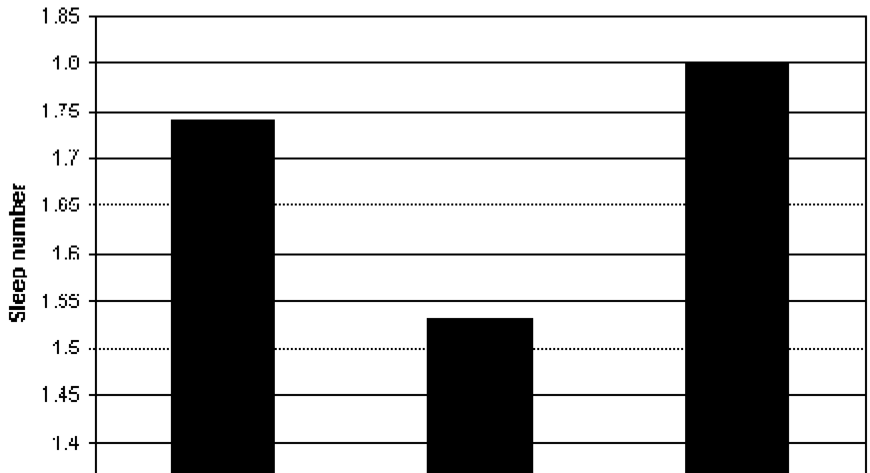
Figure 6.12 shows the number of potential sleep periods between 2200 and 0800 hours in breaks between assignments for each shipping route. Table 6.6 summarises the analysis of shipping route differences in this data. Significant differences were evident, with breaks before Inner Route (1.75 potential opportunities) and Great North East Channel (1.81 potential opportunities) assignments potentially allowing pilots more opportunity to achieve a full sleep period between 2200 and 0800 hours, compared with breaks prior to voyages on Hydrographers Passage (1.53 potential opportunities).

Contributing to this finding is the fact that on average, rest breaks prior to Hydrographer Passage assignments are significantly shorter than breaks prior to assignments on either of the other two routes (Table 6.1).

While present regulations stipulate the minimum duration of rest breaks prior to work assignments (AMSA 1997), these regulations do not consider the timing of breaks across the 24 hour cycle. Given that this issue appears to have a considerable impact on the recuperative value of breaks and hence the fatigue status of the employee, reassessment of the present regulations may be warranted.

Figure 6.13 clearly indicates that on all shipping routes, most rest breaks prior to assignments present pilots with at least one potential opportunity to achieve an 8 hour block of sleep between the hours of 2200 and 0800. However, in approximately 12% of breaks preceding Inner Route assignments, 14% prior to Great North East Channel assignments and 22% before Hydrographers Passage assignments, no opportunity for an uninterrupted period of sleep between normal sleeping hours (i.e. 2200 and 0800 hours) was available. This does not indicate that pilots were unable to achieve any sleep during the rest period. Rather, it highlights that in a number of instances sleep during rest breaks was sub-optimal in terms of its circadian placement. As a consequence, the recuperative value of the pilot's sleep would have been compromised leading to a heightened risk of fatigue and performance decrements. While it may be argued by some that marine pilots adjust to fragmented and displaced sleep, circadian adaptation to work schedules involving continual changes in work and rest times has not been evidenced in the literature (Colquhoun 1985; Colquhoun et al. 1987; Knauth & Rutenfranz 1976).

Figure 6.12 *Mean number of potential sleep periods (2200-0800 hours) in breaks between work assignments by shipping route*



Note: Data analysis based on n values shown in Methods (Section 3.2).

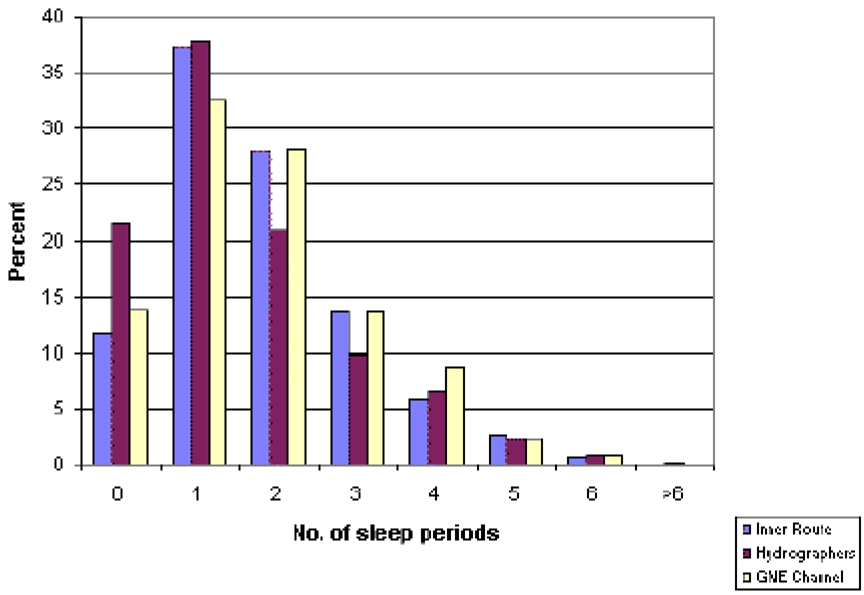
Table 6.6 *Analysis of the mean number of potential sleep periods (2200-0800 hours) in breaks between work assignments by shipping route (1)*

Effect	Post hoc results (2)	Mean + (sem)	F Statistics	p-value
			8.61	0.0002

Inner Route	1	1.75 (0.03)		
Hydrographers Passage	2	1.53 (0.05)		
Great North East Channel	1	1.81 (0.06)		

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 I Experimental Error Rate = .01).

Figure 6.13 *Frequency distribution - number of potential sleep periods (2200-0800 hours) in breaks between work assignments by shipping route*



6.9 Summary

The analysis of shipping routes highlighted that over the 18 month period, approximately 70 percent of pilotage work in the Great Barrier Reef – Torres Strait region was performed on the Inner Route. This shipping route was also associated with significantly longer transit times and involved a greater percentage of night work, and hence, may be associated with an increased risk of fatigue development.

Breaks between assignments were significantly shorter between assignments on Hydrographers Passage and significantly more travel to and from ships was incurred on the Great North East Channel. Additionally, it was identified that on all three shipping routes, approximately 12-20% of rest breaks between assignments failed to provide the opportunity for uninterrupted sleep between 2200 and 0800 hours. On all three routes, starting times of assignments and breaks were fairly evenly distributed across the 24 hour cycle, thereby highlighting the irregularity associated with pilotage work.

7.0 Results and discussion

Great Barrier Reef pilots service both the Great Barrier Reef and Torres Strait regions, thereby covering an area in excess of 345,000 square kilometers (Queensland Department of Transport & AMSA 1996). As a consequence, substantial amounts of work related travel are incurred by pilots. Given that such travel may significantly infringe upon rest time and hence, potentially impact on fatigue, as part of the present investigation an analysis of the effects of travel on the work and rest times of Great Barrier Reef pilots was performed.

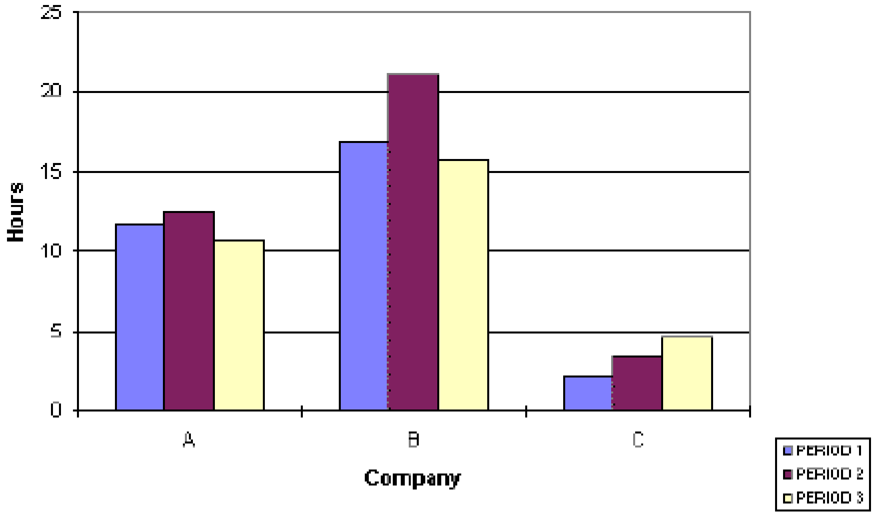
7.1 Travel time from all sources per tour

Figure 7.0 displays the mean hours of travel from all sources (to and from ships and between ports) per tour in the three time periods for each company separately. A summary of the analysis of this data in terms of company and time period differences is shown in Table 7.0. The results indicate significant differences between all of the pilotage companies in travel time per tour. The longest travel hours were recorded by Company B (17.9 hours), followed by Company A (11.7 hours) and then Company C (3.4 hours).

Between company differences in total travel time from all sources per tour are also apparent when data is presented in frequency distribution format (Figure 7.1a and Figure 7.1b). Company A's data presents as a distinct bell shaped curve, whereas data for Company B is markedly skewed. These results clearly indicate that greater amounts of travel are engaged in by Company B personnel. Given that previous sections of this report have detailed that Company B pilots perform more work assignments per tour (Table 3.3), the present finding was not unexpected.

Over the 18 months, significantly more travel was undertaken during the second 6-month period (12.2 hours) compared to the third period (10.42 hours). No clear distinction for the first period was identified from post hoc testing. Similar temporal changes in travel hours from all sources were observed for each of the companies. These results are consistent with previous findings showing an increase in work availability during the second time period.

Figure 7.0 *Mean total travel time (hours) from all sources per tour by company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 7.0 *Analysis of the mean total travel time (hours) from all sources per tour (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			66.02	0.0001
A	1	11.73 (0.471)		
B	2	17.93 (0.454)		
C	3	3.47 (0.512)		
Period (main effect)			9.37	0.0001
1	1/2	10.32 (2.294)		
2	1	12.39 (0.861)		
3	2	10.42 (0.858)		
Company * Period interaction			2.07	0.0831

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.

2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01).

Figure 7.1a *Frequency distribution - Travel time (hours) from all sources per tour per period - Company A*

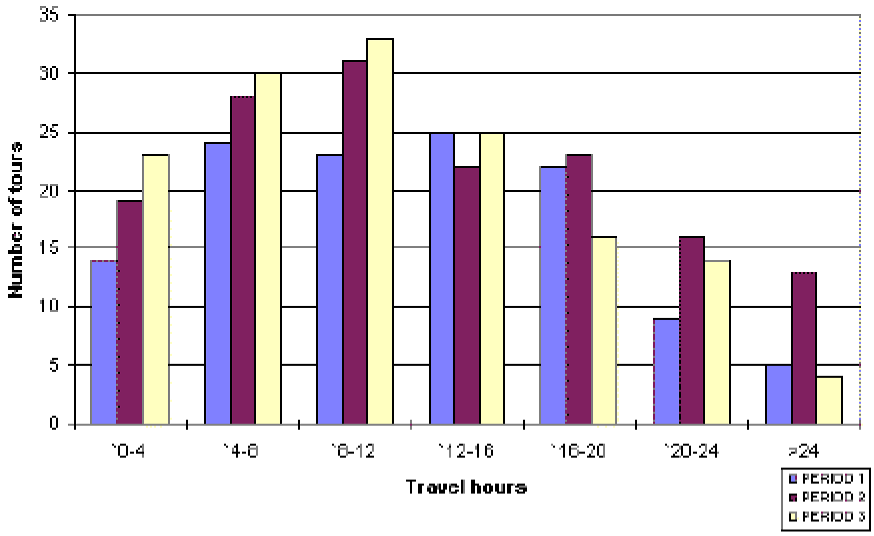
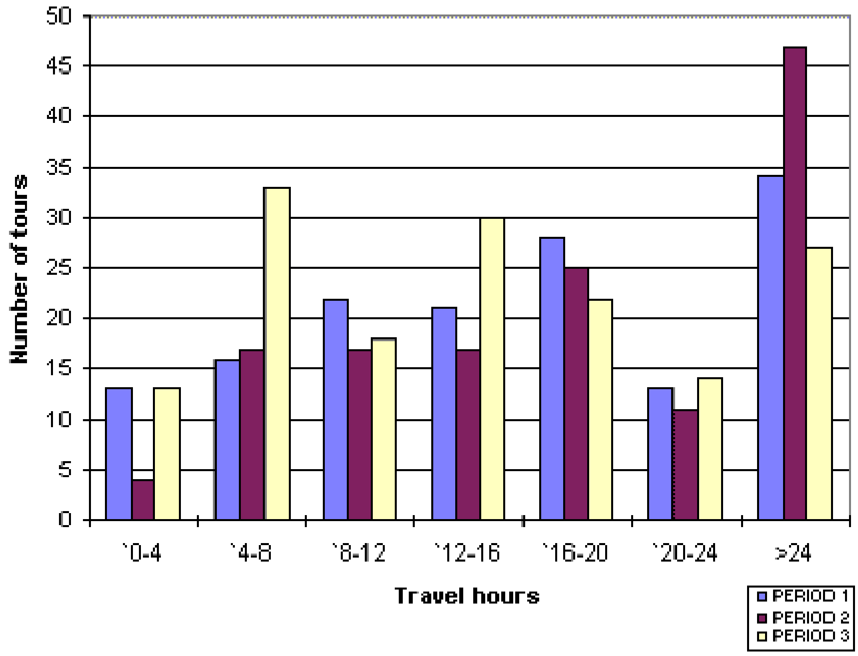


Figure 7.1b *Frequency distribution - Travel time (hours) from all sources per tour per period - Company B*



7.2 Travel time to and from ships per tour

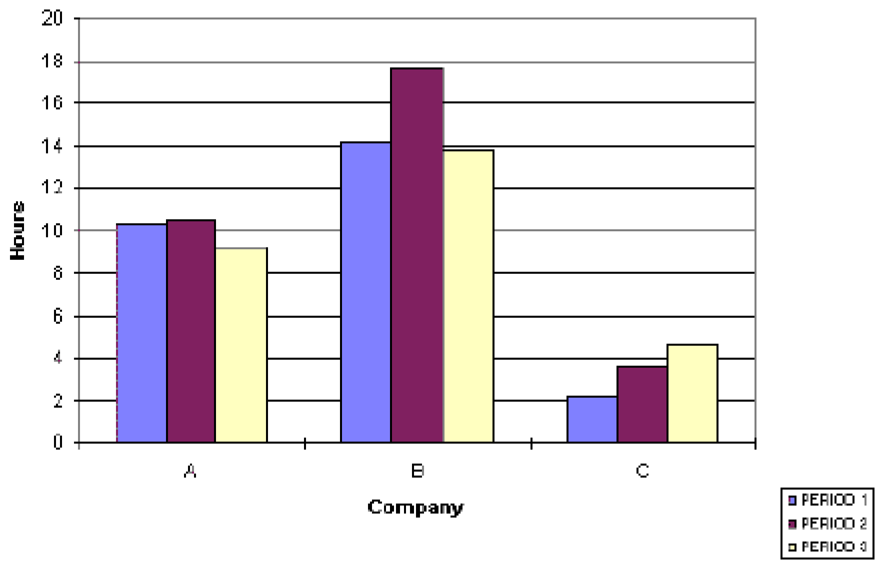
Mean travel hours to and from ships per tour for each company per 6-month period are shown in Figure 7.2, while Table 7.1 presents a summary of the analysis of this data in terms of company and time period differences. Significant differences existed with pilots from Company B spending the most time travelling to and from ships per tour of duty each 6 month period (15.2 hours), followed by pilots from Company A (10.0 hours) and then pilots from Company C (3.5 hours). These findings are consistent with the results of the previous section (Section 7.1).

When travel time to and from ships per tour for each company is presented as frequency distributions (Figure 7.3a, Figure 7.3b and Figure 7.3c), a clearer insight into company differences can be obtained. The bell shape curve depicted in Figure 7.3a shows that in most situations, tours performed by pilots from Company A involved between 4 and16 hours of travel to and from ships. In contrast, data for Company B (Figure 7.3b) presents as a flatter, more even distribution, with travel hours to and from ships per tour mostly ranging between 4 to more than 24 hours. This finding suggests that there is greater diversity in travel hours to and from ships during tours undertaken by personnel from Company B.

Data for Company C shows very little variability (Figure 7.3c), with travel time to and from ships for all tours performed during the analysis period totalling no more than 8 hours. This result is consistent with the single operational region of this company.

Changes across time were apparent with more travel being undertaken during the second time period (10.6 hours). This finding is consistent with the results of previous sections detailing an increase in work availability during the second 6-months of the 18 month analysis. The same temporal pattern was exhibited by all companies.

Figure 7.2 *Mean total travel time (hours) to and from ships per tour by company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 7.1 *Analysis of the mean total travel time (hours) to and from ships per tour (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean + (sem)	F Statistics	p-value
Company (main effect)			67.25	0.0001
A	1	10.00 (0.384)		
B	2	15.17 (0.370)		
C	3	3.47 (2.047)		
Period (main effect)			7.65	0.0005
1	1/2	8.86 (1.870)		
2	1	10.57 (0.701)		
3	2	9.22 (0.700)		
Company * Period interaction			2.03	0.0884

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. P < 0.01 considered statistically significant.
2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01).

Figure 7.3a *Frequency distribution - travel time (hours) to and from ships per tour per period - Company A*

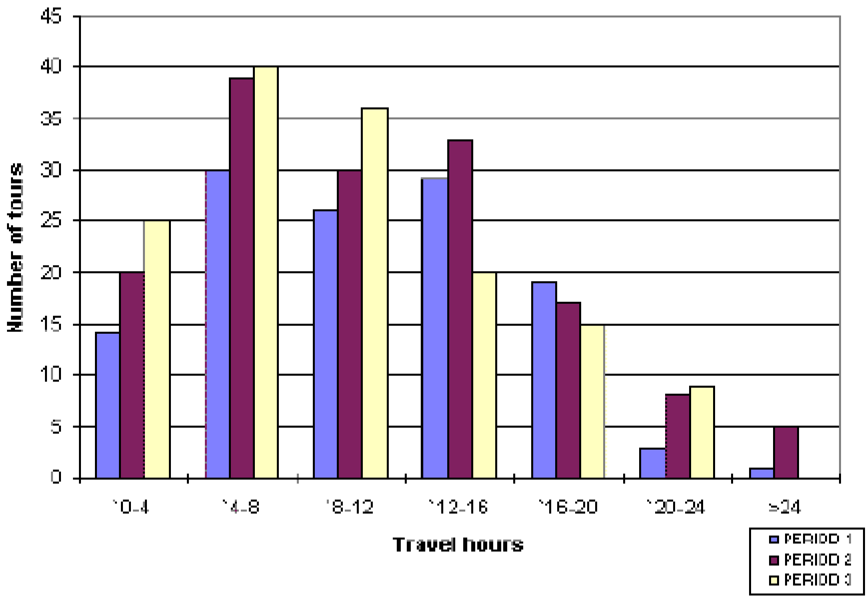


Figure 7.3b *Frequency distribution - travel time (hours) to and from ships per tour per period - Company B*

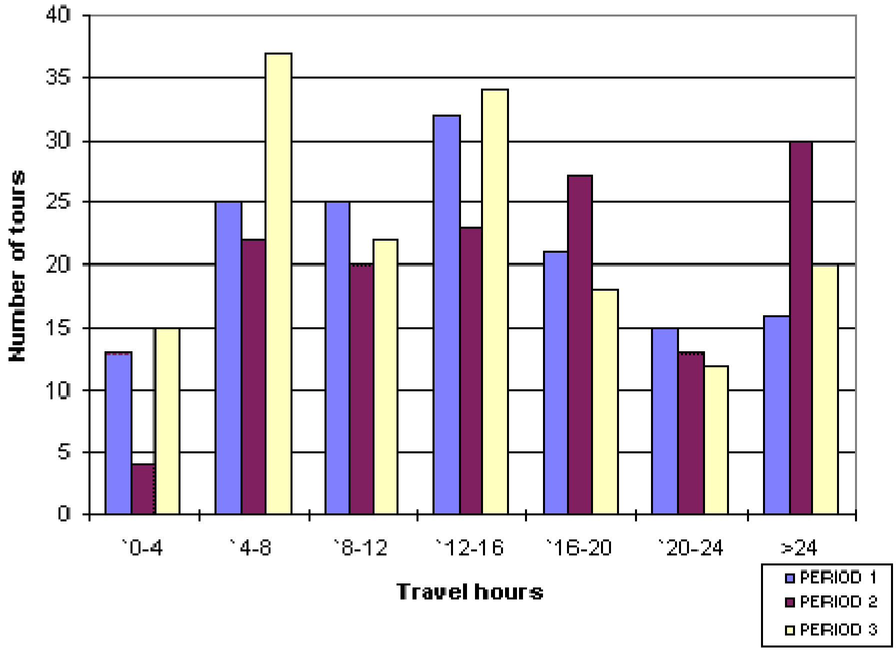
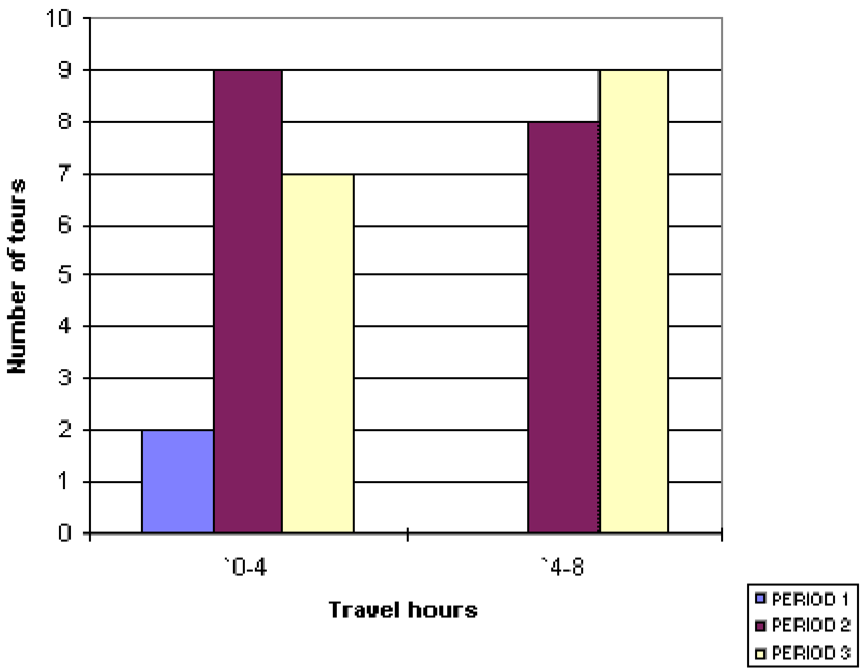


Figure 7.3c *Frequency distribution - travel time (hours) to and from ships per tour per period - Company C*



7.3 Travel Time between Ports per Tour

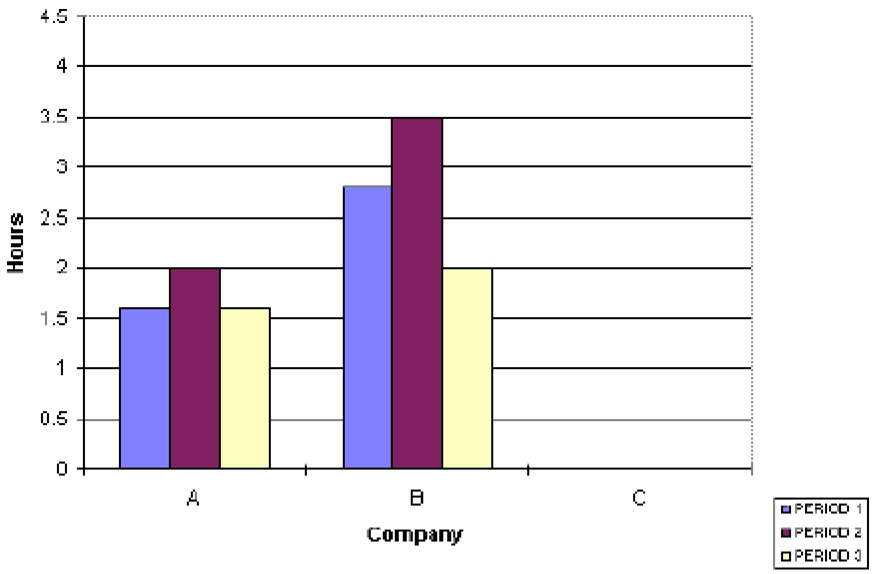
Pilotage in the Great Barrier Reef - Torres Strait region involves joining ships at various ports and boarding grounds along Queensland's north-eastern coastline. As a consequence, after completing a work assignment, pilots are frequently required to travel (via aircraft) to another location for embarkation on the next ship.

For each of the pilotage companies the mean hours of travel between ports per tour across the three time periods is presented in Figure 7.4. Table 7.2 shows a summary of the analysis of this data indicating company and period differences. Post hoc testing indicated Company B pilots experienced significantly greater hours of travel between ports (2.76) than Company A (1.72). The absence of travel between ports for Company C reflects the single operational region of this company. That pilots from Company B have also been found to perform more work assignments per tour (Table 5.0) most likely contributes to the greater amount of travel between ports per tour recorded for this group of pilots.

The frequency distributions of travel time between ports show that for both Companies A and B, the majority of tours involved 4 hours or less travel between ports (Figure 7.5a and Figure 7.5b). However, a small number of tours, particularly in the data for Company B, can be identified in which travel between ports totalled 8 hours or more. This extra travel could potentially encroach on recovery time between work assignments and hence may contribute to an increased risk of fatigue development.

In terms of changes across time, longer hours of travel between ports were recorded in the second time period (1.82) compared with the third period (1.2). No clear distinction for the first period was made from post hoc testing. The pattern of temporal changes was similar for the two companies which travelled between ports (Table 7.2) and is clearly depicted in Figure 7.4. This result is consistent with the increased work availability during the second 6 month period.

Figure 7.4 *Mean total travel time (hours) between ports, per tour (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 7.2 *Analysis of the mean total travel time (hours) between ports per tour by company and period (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean + (sem)	F Statistics	p-value
Company (main effect)			26.43	0.0001
A	1	1.72 (0.133)		
B	2	2.76 (0.128)		
C	3	0.00		
Period (main effect)			8.43	0.0002
1	1/2	1.46 (0.649)		
2	1	1.82 (0.243)		
3	2	1.20 (0.243		
Company * Period interaction			1.92	0.1054

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. p < 0.01 considered statistically significant.
2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01).

Figure 7.5a *Frequency distribution - Travel time (hours) between ports per tour per period - Company A*

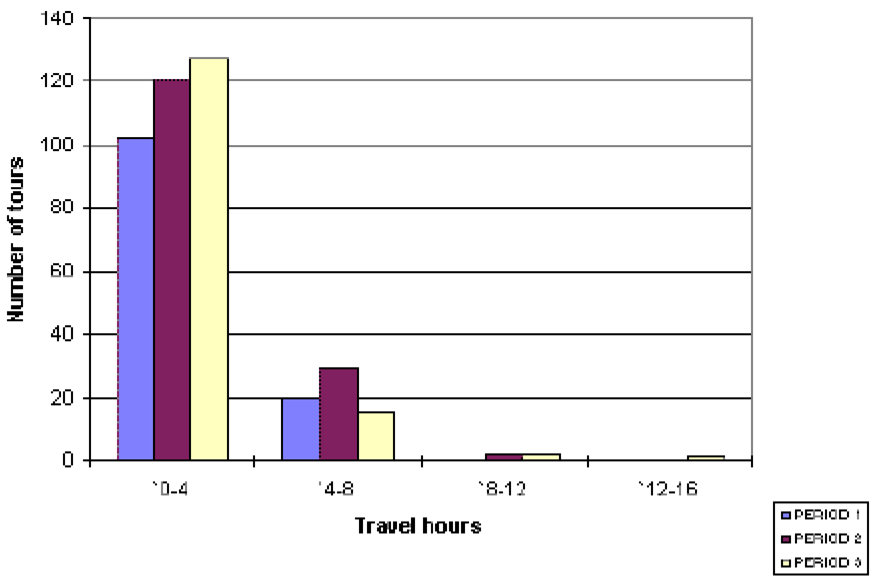
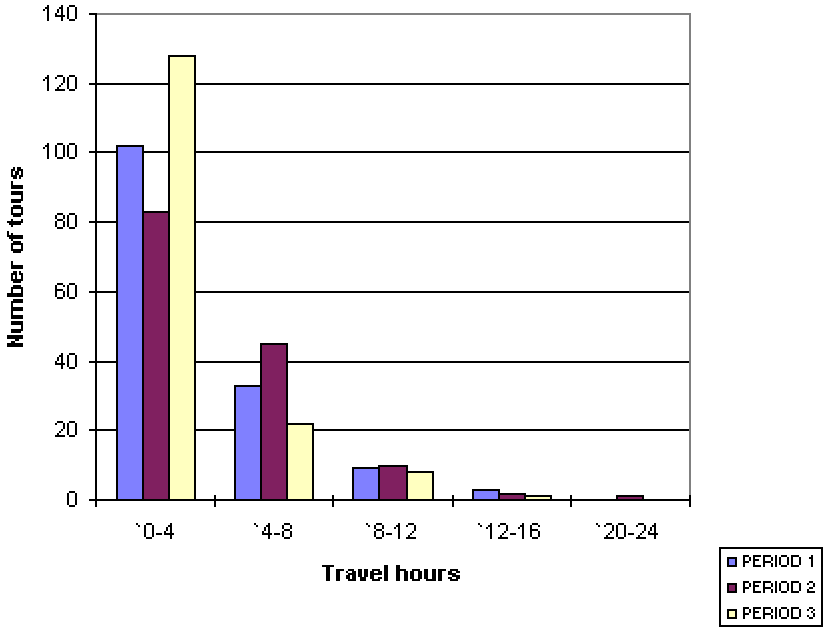


Figure 7.5b *Frequency distribution - Travel time (hours) between ports per tour per period - Company B*



7.4 Travel Time To and From Ships per Work Assignment

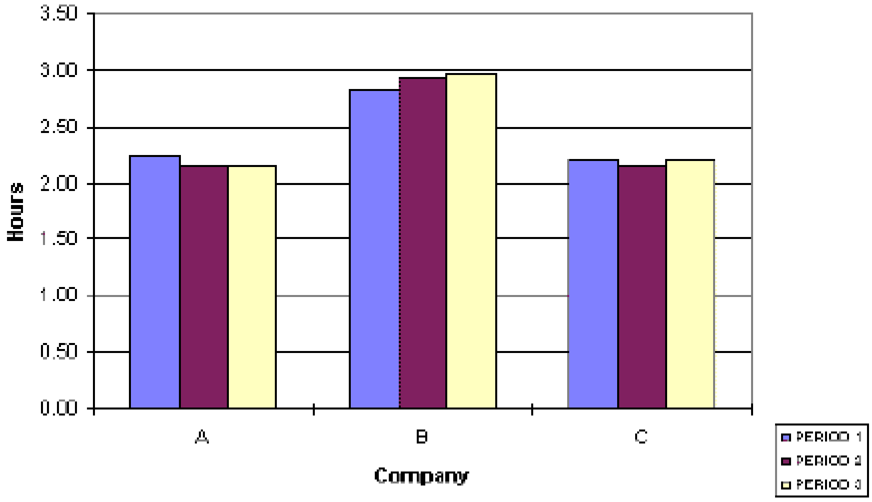
One of the unique features of pilotage work in the Great Barrier Reef - Torres Strait region is the duration of travel to and from boarding grounds. Launch trips can take up to 3 hours in duration, while some helicopter flight times involve around 2 hours of travel.

Figure 7.6 depicts average travel time to and from ships per assignment for each company across the three 6 month periods, while Table 7.3 presents a summary of the analysis of company and period differences in this data. Post hoc testing revealed the source of the significant inter-company difference in travel. Pilots from Company B engaged in more hours of travel per work assignment (2.9 hours), compared with pilots from Companies A (2.2 hours) and C (2.2 hours), which were similar. This result is consistent with the greater amounts of travel (Table 7.1 and Table 7.2) and greater number of work assignments (Table 5.0) previously reported for Company B pilots.

Several possible factors could contribute to the longer hours of travel per work assignment recorded by pilots from Company B. Firstly, it is possible that personnel from Companies A and C may more frequently board vessels when they are docked at ports and in this way avoid travelling out to boarding grounds. Secondly, differences between companies in the mode of transport used to reach particular boarding grounds could substantially influence travel time. For example, if Company A used helicopters where Company B used launch vessels, travel time for the former group would be substantially shorter. Thirdly, Company B personnel may perform a greater number of work assignments which begin or end at more distant boarding grounds in the Torres Strait and North East Channel regions than pilots from Companies A and C.

In terms of changes in travel time to and from work assignments over the three by 6 month periods, no significant differences were found (Table 7.3). This result was observed for each of the pilot companies.

Figure 7.6 *Mean travel time (hours) to and from ship per work assignment by company and period (1 Jan 1996 - 30 June 1997)*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 7.3 *Mean total travel time (hours) to and from ships, per work assignment (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			444.32	0.001
A	1	2.18 (0.0.19)		
B	2	2.91 (0.017)		
C	1	2.19 (0.203)		
Period (main effect)			1.24	0.2889
1	n/a	2.42 (0.192)		
2	n/a	2.41 (0.053)		
3	n/a	2.443 (0.047)		
Company * Period interaction			3.66	0.005

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects. $p < 0.01$ considered statistically significant.
2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01) n/a Post hoc testing not performed when main effect not significant.

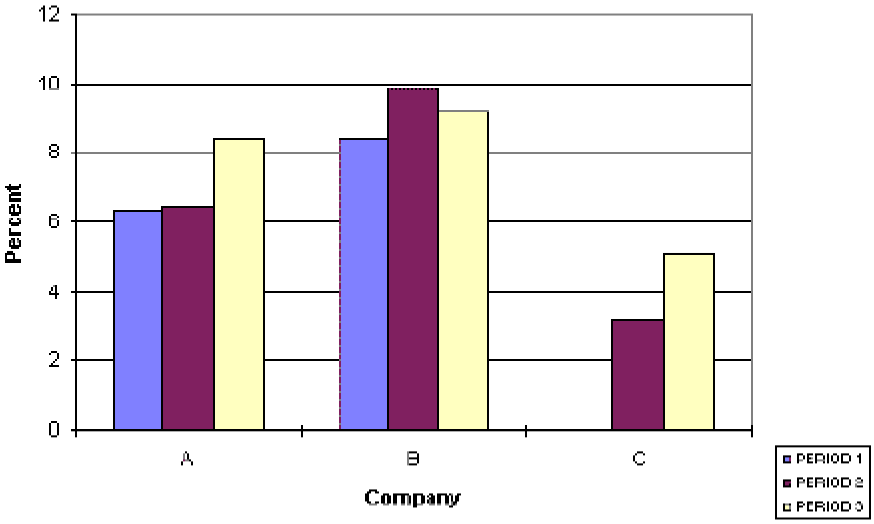
7.5 Percent of breaks between assignments spent travelling (to and from ships and between ports)

Figure 7.7 reveals the percent of breaks between ships spent travelling for each 6-month period for each company separately. Table 7.4 summarises the analysis of this data in terms of between company and time period differences. A greater percentage of Company B's breaks between work assignments were spent travelling (9.2%), followed by Company A (7.0%) and then Company C (4.4%). These results are consistent with the findings reported previously (Sections 7.1, 7.2 and 7.3).

On average, pilots from Companies A and B spend just under 10% of their breaks between work assignments travelling. Hence, if a pilot had 24 hours between time of disembarkation to time of next embarkation, it could be estimated that around 2 hours of travel would be engaged in. While this does not sound like a substantial amount, travel tends to be fragmented throughout the rest period. This in turn limits the pilot's opportunity for continuous rest and/or sleep and diminishes the recuperative value of the recovery period. Hence it is the fragmented nature of travel, rather than the actual volume of travel which most likely has the greatest impact on the pilot's recovery.

There were no significant differences in the percent of breaks between work assignments spent travelling across the 18 month analysis period. It is therefore apparent that the increased amounts of travel engaged in by pilots during the second 6 month period were negated by the increased work availability in this period. The same temporal pattern was observed in each of the pilotage companies.

Figure 7.7 *Mean percent of breaks between work assignments spent travelling per Company per period*



Note: Data analysis based on n values shown in Methods (Section 3.2).

Table 7.4 *Analysis of the percent of breaks between work assignments spent travelling (1 Jan 1996 - 30 June 1997) (1)*

Effect	Post hoc results (2)	Mean (sem)	F Statistics	p-value
Company (main effect)			4.68	0.009
A	1	7.04 (0.800)		
B	1	9.23 (0.212)		
C	1	4.42 (0.652)		
Period (main effect)			1.05	0.348
1	n/a	7.47 (0.181)		
2	n/a	8.29 (0.165)		
3	n/a	8.76 (1.068)		
Company * Period interaction			0.79	0.499

1. Results of full two-way analysis of variance (ANOVA) model including company and period effects.

2. Results of Tukey's Studentised Range Test for post-hoc differences (Type I Experimental Error Rate = .01) n/a Post hoc testing not performed main effect not significant.

7.6 Summary

The description of travel indicates a significant provider effect with pilots from Company B experiencing greater amounts of travel to and from ships, between ports and from all sources. It was also noted that a greater percentage of Company B's breaks between assignments was spent travelling. These findings are consistent with the greater time spent on tours, greater number of work assignments and shorter rest breaks reported for this pilotage group. That Company B personnel experienced significantly longer hours of travel to and from ships per work assignment suggests that company differences exist in either the mode of transport used to reach boarding grounds or the number of assignments performed which begin or end at more distant boarding grounds.

While on average, less than 10% of break times were spent travelling, that travel is probably fragmented throughout the recovery period most likely creates the greatest impact on the pilot's recovery. The fragmented nature of the travel causes rest and sleep to be discontinuous, thereby reducing the recuperative value of breaks.

With regards to changes across time, travel hours to and from ships per tour and between work assignments per tour significantly increased during the busy second 6 month period. However, no variations across time were found in the relative amount of break time spent travelling. Thus it would appear that the increased travel reported for the second time period directly related to the increased work availability during this period.

Section 8

Overall Summary

Recent marine investigations have shown an increase in the number of fatigue related incidents. Given the environmental sensitivity of the Great Barrier Reef pilotage region, the Australian Maritime Safety Authority initiated a study to investigate the fatigue aspects of the work practices of Great Barrier Reef pilots. Three pilotage companies representing 60 pilots work in this region.

The initial step in identifying the fatigue aspects of the work practices involved analysing retrospective work schedule files for an 18 month period (January 1, 1996 to June 30, 1997). The files were based on 4310 work assignments performed during 902 tours of duty. Essentially, the analysis developed a description of ship and non-ship time of Great Barrier Reef pilots and highlighted the characteristics of tours of duty, work assignments, shipping routes and work-related travel.

Tours of duty involve pilots undertaking one or more work assignments and alternating between living at sea and ashore while on tour. In general, pilots spent around 18 days on a tour and had 10 to 20 days at home between tours. Approximately 50 percent of tour time was spent undertaking work assignments (ship time).

Work assignments represent a continuous period of time when pilots are on board ships. There were significant company differences on several measures. For example, Company B performed 31% more work overall, and 51% more work on the Inner Route than Company A. For all three pilotage companies, approximately 50% of work assignment time was at night. Starting times of work assignments and breaks for all three companies were fairly evenly distributed across all 4 hour time periods within the 24 hour cycle. This finding highlights the irregularity of marine pilotage work.

Characteristics of the three main shipping routes serviced by Great Barrier Reef marine pilots also have the potential to impact on fatigue status. For example, Inner Route assignments were significantly longer and involved a higher percentage of night work than the other two routes, while assignments on the Great North East Channel involved significantly greater amounts of travel.

A unique feature of Great Barrier Reef pilotage is the extensive amount of work-related travel incurred, particularly to and from ships. After inclusion of travel in the work schedule analysis, it was shown that work assignment duration and percentage of night work significantly increased, while breaks between assignments decreased.

The work schedules findings identified a significant number of instances when considerably greater workloads and shorter breaks were experienced by pilots. While these instances were not commonplace, the heightened fatigue potential and increased risk of accident associated with such work conditions makes these findings of concern, particularly in view of the competition in pilotage operations in this region.

Based only on ship time and non-ship time, the analysis showed a high presence in the work schedules of potential fatigue indicators. These included the irregularity of work and rest breaks, the percentage of ship time performed at night and work and sleep displacement from the normal circadian cycle. There were also a number of situations in which workloads considerably greater than that shown in group data was found. Additionally in many situations, the duration of breaks between assignments was unlikely to accommodate complete recovery from the fragmented sleep patterns experienced by pilots while at sea.

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Appendix 1

Methods

Measure	Definition	Calculation (if applicable)
Tour of duty	One or more work assignments defined by the time between the first embarkation to the last disembarkation.	Tours were delineated according to breaks between assignments: when there were 7 or more days break between consecutive work assignments it was determined that a new tour had commenced; 3 or fewer days break between work assignments were considered to

		represent a continuation of a tour; 3-7 day breaks were individually assessed.
Tour duration	Length of tour of duty.	Defined by the time between the first embarkation to the last disembarkation (based on the definition of a tour).
Tour breaks	Length of time between tours of duty.	Calculated from the last disembarkation of one tour to the first embarkation of the next (based on the definition of a tour).
Work assignment	A continuous period of time when a pilot is on board ship.	
Work assignment duration	Number of hours spent on the ship.	Measured from embarkation to disembarkation and adjusted for travel to and from the ship.
Breaks between assignments	Non-ship time.	Calculated from disembarkation to embarkation.
Day and Night Time Periods	Day time period extended from 0525 and 1818.	Based on the civil twilight hours averaged across 12 months and three areas in the Great Barrier Reef region.
Night hours for assignment	Period of time between 1818 and 0525 spent on ship.	Based on the definitions of night time periods and work assignments.
Travel to and from a tour	Hours of travel from home to the port location of the first work assignment of a tour and from the disembarkation point of the final work assignment of a tour to home.	Calculated from information regarding the location of the pilot's home residence and airline schedules. This time was not regarded as work.
Travel between ports	Hours of travel from one port ashore to the next port.	Calculated from airline schedules regarding the duration of flight times between ports.

		Determined as work time in the analysis.
Travel to and from work assignments	Travel from port to boarding ground to meet ship and from boarding ground back to port.	Calculated from information supplied by pilotage companies regarding travel duration to and from boarding grounds. Mode of travel was not considered.

Appendix B

List of tables

Appendix C

List of Figures