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16. Abstract

To enhance the efficiency and productivity of its Arctic icebreaking operations, the Department of Fisheries and Oceans/Canadian Coast Guard (DFO/CCG) wished to extend crewing periods from 28 to 42 days. To examine whether this could be done without compromising crew and vessel safety, the current study examined changes in crew state during two 28-day and two 42-day periods aboard the icebreakers Sir Wilfrid Laurier and Pierre Radisson.

The study focused on bridge and engineering watchkeepers. The results indicated some deterioration in crew state (perceived performance degradation by the crew; increased frustration, withdrawal, irritability, and apathy; and some indication of reduced sleep, particularly after week 4) associated with extending the crewing period beyond 28 days. Crew state was moderately better for personnel on the 12&12 watch compared to the 4&8 watch. Day watch personnel reported a better crew state than the night watch personnel. Icebreaking activity was an important factor, with more icebreaking or icebreaking activity late in the crewing period having a greater negative impact on crew state.

Strategies and interventions were provided to cope with watch work and fatigue. These included recommendations to improve sleep when working watches, eating guidelines, the role of fitness and well-being, relaxation techniques, and natural biological therapies. As part of the recommendations, the study indicated that if implemented, extended crewing periods should be monitored to ensure that there is no detrimental effect on crew state or human performance.

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16. Résumé

En vue d'améliorer l'efficacité et la productivité de ses opérations de déglaçage dans l'Arctique, Pêches et Océans Canada/Garde côtière canadienne (POC/GCC) désire prolonger les affectations en mer de 28 jours à 42 jours. La présente étude vise à déterminer si ce prolongement peut être effectué sans mettre en péril la sécurité des navires et de leur personnel par l'observation de tout changement dans la condition des membres de l'équipage durant deux affectations de 28 jours et deux affectations de 42 jours, à bord des brise-glace Sir Wilfrid Laurier et Pierre Radisson.

L'étude a porté principalement sur le personnel de quart en poste sur la passerelle et dans la salle des machines. Les résultats ont mis en lumière une détérioration de la condition de l'équipage (le sentiment, exprimé par les membres de l'équipage, que leur rendement diminuait; l'augmentation de la frustration, du repli sur soi, de l'irritabilité et de l'apathie; et certains indices d'une perte de sommeil, plus particulièrement après la quatrième semaine) lors du prolongement de l'affectation au-delà de 28 jours. La comparaison avec les données recueillies dans le cas de l'horaire «quatre-huit» indiquerait une amélioration modérée de la condition de l'équipage travaillant selon l'horaire «douze-douze». Le personnel effectuant les quarts de jour semblait en meilleure condition que l'équipage travaillant de nuit. La durée des opérations de déglaçage est un facteur important, leur effet négatif sur la condition de l'équipage étant plus prononcé lorsqu'elles sont effectuées à la fin de l'affectation en mer.

Les stratégies et les mesures à prendre pour assurer l'exécution du travail malgré l'état de fatigue sont définies dans ce rapport. Y figurent également des recommandations en vue d'améliorer le sommeil du personnel travaillant par quart, des lignes directrices en matière d'alimentation, des observations sur l'importance de la condition physique et du bien-être, des techniques de relaxation et de la biothérapie. Parmi ces recommandations, il est mentionné que d'éventuelles affectations prolongées en mer devraient faire l'objet d'un suivi afin de garantir qu'elles n'ont pas d'effets néfastes sur la condition de l'équipage et sur la performance humaine.

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EXECUTIVE SUMMARY

To enhance the efficiency and productivity of its operations, the Department of Fisheries and Oceans/Canadian Coast Guard (DFO/CCG) wished to investigate whether crewing periods could be extended from 28 to 42 days without compromising crew and vessel safety. To examine the level of risk to crew and vessel safety, crew state was examined during 28- and 42-day periods aboard the icebreakers Sir Wilfrid Laurier and Pierre Radisson respectively. Specific human performance measures for bridge and engineering watchkeepers included measures of cognitive performance, sleep, fatigue, and socio-psychological well-being.

In addition to the central question concerning extended crewing periods, a number of other issues were explored to determine whether various aspects of CCG operations might promote or inhibit the onset of performance impairment. Factors included: watch type; the impact of prolonged versus shorter icebreaking operations; the relative time (early or late) of icebreaking operations within the patrol; the influence of workload; and the physiological adaptation of persons to different watch schedules. These issues are potentially significant modifiers of fatigue effects.

As part of the study, a task analysis was conducted on bridge and engineering watchkeepers to identify the types of tasks and modes of operation (e.g., icebreaking, SAR (Search and Rescue)) in which fatigue effects are of the greatest potential concern. Using Fleet Activity Information System (FAIS) data, levels of vessel workload were compared to determine if the workload observed during the data collection period in 1996 was representative of that for the previous year. The results of the investigation can be summarized as follows:

- Signs of apparent deterioration in crew state began to emerge when the crewing periods were extended from 28 to 42 days. These included: perceptions by the crew that their performance was starting to degrade; increased frustration, withdrawal, irritability, and apathy; and some indication of reduced sleep, particularly after week 4.
- Compared to the 4&8, crew state appeared moderately better on the 12&12 watch, based on the measures of sleep, fatigue, mood, and group dynamics and morale. Although personnel on the 12&12 watch schedule reported higher workloads, they were more satisfied with their performance, more cheerful, and recorded better group dynamics and morale. The personnel on the 4&8 ship reported greater frustration, degraded task and mental performance, more withdrawal, and greater irritability.

- Compared to the night watch, crew state was somewhat better for personnel on the day watch (based on cognitive, sleep, fatigue, and socio-psychological measures, as well as additional measures including symptoms). Situational awareness was better for personnel on the day watch. They reported lower levels of frustration and had more sleep (up to 100 minutes per day) than personnel on the night watch. Day watch personnel were also more cheerful, calm and confident, had higher morale, and felt that they responded better to stress. The differences between the day and night personnel may be due to cumulative sleep debt, because objectively (i.e., NightCap data) night crew obtained only approximately five hours sleep per 24-hour period.

- The duration of icebreaking activity in a crewing period is an important factor on crew state. When crew were exposed to a total of 8 compared to 15 days of icebreaking in a crewing period, the latter had a more negative impact on crew state. A total of 15 days of icebreaking was associated with crew falling asleep faster, perception of degraded mental performance, as well as greater frustration, irritability and withdrawal.

- When performed late in the crewing period, the negative effect of icebreaking on crew state was greater than that observed when icebreaking took place early in the crewing period.

- After three weeks, the circadian rhythms of crew on the 4&8 night watch were more variable and did not show signs of adapting to a night watch. However, this information is based on only two case studies. Further study of the circadian rhythms of crew members on various watch schedules is needed to obtain conclusive findings.

These findings indicate that there are some negative effects associated with extended crewing periods. Although the magnitude of these effects may not be sufficient to preclude the implementation of longer patrols, there is potential for greater negative impact on human performance if the workload is increased beyond that observed in the present study.

Strategies and interventions to cope with shift work and fatigue, particularly in relation to marine watchkeeping, are provided in the report. Also included are recommendations to improve sleep when working watches, eating guidelines, the role of fitness and well-being, relaxation techniques, and natural biological therapies.

Recommendations

Based on the results of this study, the following recommendations are provided:

- Extended crewing periods should be implemented in an organized manner including continued evaluation of the effects of extended crewing on human performance.

- Introduction of a 12&12 watch schedule should be considered for Arctic icebreaking operations because it offers a better opportunity for improved watch management through modifications to procedures during relatively low workload periods. The 12&12 watch schedule also provides the opportunity for a longer, uninterrupted period to sleep.
- Crewing requirements should be matched to anticipated workload so that the crew can achieve maximal sleep and rest.
- Crew should be provided with opportunities for strategic rest periods or to take naps so that they can achieve maximal sleep and rest.
- Opportunities for crew to rest should be provided during periods of extended icebreaking.
- If icebreaking is late in the duty cycle, additional rest and extra precaution are required.
- Crew preference must be considered before implementing a 12&12 schedule, particularly if it is in a region unfamiliar with this type of watch.
- If 12&12 watches are implemented, vigilance testing is recommended to assess the impact on human performance.
- During weeks 5 and 6 of an extended crewing period, tasks identified by the task analysis as sensitive to fatigue should be minimized wherever possible.
- Tasks identified as sensitive to fatigue by the task analysis should be minimized at night until further circadian rhythm data are collected.
- A training program should be implemented to provide crew with information about coping strategies that will help them deal effectively with extended crewing periods.
- Older crew members should be assigned to day watches, as aging affects an individual's ability to adapt to changes in their sleep pattern.
- Sufficient time off needs to be provided between successive 42-day cycles, to ensure that crew can recover adequately.

TABLE OF CONTENTS

1 INTRODUCTION ... 1

1.1 Background ... 1

1.2 Fatigue and Human Performance in Marine Operations ... 2

1.3 Circadian Rhythms ... 3

1.4 Circadian Rhythms and Sleep ... 3

1.5 Circadian Rhythms and Performance ... 4

1.6 Fatigue and Performance ... 5

1.6.1 Compensatory Effects ... 5

1.6.2 Task Demands ... 6

1.7 Other Behavioural, Psychological, and Situational Factors ... 6

1.8 Recent Studies in the Marine Environment ... 7

1.9 Report Layout ... 8

2 EXPERIMENTAL METHODOLOGY ... 9

2.1 Ships ... 9

2.1.1 Sir Wilfrid Laurier ... 9

2.1.2 Pierre Radisson ... 9

2.1.3 Watchkeeping Schedules ... 9

2.2 Crew ... 10

2.3 Procedures ... 11

2.3.1 Participants ... 11

2.3.2 Measures ... 13

2.4 Analysis ... 15

2.4.1 Grouping of Crew ... 15

2.4.2 Data Analysis ... 17

3 RESULTS AND DISCUSSION 19

3.1 Differences between the 28- and 42-Day Crewing Periods 19

3.1.1 Cognitive Assessment 19

3.1.2 Sleep 24

3.1.3 Fatigue 25

3.1.4 Socio-Psychological Factors 26

3.1.5 Additional Measures 27

3.1.6 Summary of the Differences between the 28- and 42-Day Crewing Periods 28

3.2 Differences between 4&8 and 12&12 Watches 29

3.2 1 Cognitive Assessment 29

3.2.2 Sleep 29

3.2.3 Fatigue 30

3.2.4 Socio-Psychological Factors 31

3.2.5 Additional Measures 31

3.2.6 Summary of the Differences between 4&8 and 12&12 Watches 31

3.2.7 Comparison of 4&8, 6&6, and 12&12 Watches 32

3.3 Differences between Day and Night Watches 33

3.3.1 Cognitive Assessment 33

3.3.2 Sleep 34

3.3.3 Fatigue 34

3.3.4 Socio-Psychological Factors 34

3.3.5 Additional Measures 35

3.3.6 Summary of the Differences between Day and Night Watches 35

3.4 The Impact of 8 versus 15 Days of Icebreaking 35

3.4.1 Cognitive Assessment 36

3.4.2 Sleep 36

3.4.3 Fatigue 37

3.4.4 Socio-Psychological Factors 37

3.4.5 Additional Measures 37

3.4.6 Summary of the Impact of 8 versus 15 Days of Icebreaking 38

3.5 The Impact of Icebreaking Early Compared to Late in the Crewing Cycle 38

3.5.1 Cognitive Assessment 38
3.5.2 Sleep 39
3.5.3 Fatigue 39
3.5.4 Socio-Psychological Factors 39
3.5.5 Additional Measures 40
3.5.6 Summary of the Impact of Icebreaking Early in the Crewing Period as Opposed to Late 40
3.6 Body Temperature Shifts for Night Workers (Adaptation or Re-entrainment) 41
3.7 Fleet Activity Information System (FAIS) 43
3.8 Task Analysis 44
4 SUMMARY 45
5 RECOMMENDATIONS 47
6 LIMITATIONS OF THIS STUDY 49
6.1 Limitations Related to Operational Issues and Crewing Characteristics 49
6.2 Limitations Related to Crew Participation 50
7 REFERENCES 51
APPENDIX A Work Plan: Study on Extended Crewing Periods
APPENDIX B Difference between the 28 and 42 Day Crewing Periods
APPENDIX C Difference between 4&8 and 12&12 Watches
APPENDIX D Difference between Day and Night Watches
APPENDIX E The Impact of 8 versus 15 Days of Icebreaking
APPENDIX F The Impact of Icebreaking Early as Opposed to Late in the Crewing Period
APPENDIX G Body Temperature Shifts for Night Workers (Adaptation or Re-entrainment)
APPENDIX H FAIS Analysis of Vessel Activity
APPENDIX I Task Analysis of Bridge and Engine Room Watchkeepers
APPENDIX J Coping Strategies

LIST OF TABLES

Table 2.1: Watch rotation schedules for the Laurier and Radisson. 10

Table 2.2: Summary of crew members from the Laurier and Radisson who participated in the study. 10

Table 2.3: Summary of recommended data collection periods including measures and participants. 12

Table 2.4: Summary of data collection procedures. 16

Table 3.1: Summary of the number of trials and number of subjects who participated in the Essex study. 20

Table 3.2: Mean response times obtained from crew on board icebreakers compared by week to data provided by the Essex Corporation. 21

Table 3.3: Comparison of the mean percent correct obtained on the Delta performance test in the Essex study compared to the present study. 21

Table 3.4: Comparison of 6&6, 4&8, and 12&12 watch schedules on measures of sleep, alertness, and cognitive performance. 32

Table 3.5: Icebreaking periods for the Laurier and Radisson. 36

LIST OF FIGURES

Figure 3.1: Mean response time (sec.) on the computerized cognitive performance tests (Delta) for Group 1, as a function of weeks at sea.....20

Figure 3.2: Mean percentage of failures on the Delta tests as a function of weeks at sea (weeks two to five).....22

Figure 3.3: Mean subjective workload ratings (NASA TLX) for Group 1 for visual and overall workload.....23

Figure 3.4: Mean subjective workload ratings (NASA TLX) for Group 1.....24

Figure 3.5: Average sleep duration (minutes) over weeks 2 to 6.....25

Figure 3.6: Commanding Officer's (CO's) and Chief Engineer's (CE's) ratings of crew workload and fatigue for Group 1.....26

Figure 3.7: Post-watch mood ratings for Group 1.....27

Figure 3.8: Highest and lowest recorded body temperatures for participant number 109, watch 3 aboard the Radisson.....42

Figure 3.9: Highest and lowest recorded body temperatures for participant number 110, watch 3 aboard the Radisson.....42

1 INTRODUCTION

When examining the issues of watch scheduling and fatigue, personnel working on board Coast Guard ships that are deployed to the Arctic are in a unique situation. When on Arctic Operations, Coast Guard employees are on board the vessel for the duration of the on-duty work cycle (i.e., 28 days, 42 days or longer) without being exposed to the potential stress and distraction of going home every day. In addition, when the vessel departs from its home port, the personnel (particularly the ship's officers) have the potential to adapt their daily routine to match the assigned watch for the duration of the on-duty work cycle. This may have advantages over the typical shore-based shift workers who go home after every shift, or who work for only a few days before having to change to another shift. However, the extent to which the prolonged crewing period in Arctic icebreaking operations affects crew state is largely unknown.

To determine the extent to which extended crewing periods affect aspects of crew state, the Transportation Development Centre (TDC), Transport Canada, contracted B.C. Research Inc. (BCRI) to compare crew state for personnel who were on board CCG icebreakers which had 28- and 42-day crewing periods. The vessels which were investigated were the Sir Wilfrid Laurier and the Pierre Radisson.

1.1 Background

Fatigue effects associated with shiftwork, watchkeeping, and sustained operations are of increasing concern in terms of performance levels and safety. With an aging work force, staff reductions, and increases in monitoring tasks related to automated technologies performed around the clock, fatigue effects have become a significant problem in today's work force. The recent catastrophic systems failures of Chernobyl, the space shuttle Challenger, and the Exxon Valdez have in large part been attributed to fatigue. These incidents underscore the critical importance of developing a thorough understanding of human capabilities and limitations in relation to fatigue, shiftwork, and watchkeeping in modern work environments.

Sustained operations and watchkeeping schedules in the marine environment are of particular concern. The earliest literature on marine watchkeeping, from the thirteenth century, documents the traditional 4h on/4h off schedule. Much of the basis for having a 4h work period was the extent of physical labour and exposure to harsh environmental conditions. With advances in technology and changes to the nature of task characteristics, longer watches became possible. In more recent years, alternate watchkeeping schedules and extended crewing periods have been examined in relation to crew performance and fatigue levels.

Recently, TDC compared the impact of two watch schedules (6&6 versus 4&8) on Canadian Coast Guard (CCG) watchkeepers for a 28-day crewing period (Donderi *et al.*, 1995). In this study entitled "Shift Schedule Comparison for the Canadian Coast Guard", measures of performance were choice reaction time and short-term memory. Measures of well-being included ratings of mood, alertness and sleep quality, as well as personal sleep diaries. Although crew on the 4&8 watch obtained longer periods of uninterrupted sleep, measures of total sleep time, performance, and mood did not differ significantly for the two schedules. However, on the basis of their findings, it was recommended that a modified 4&8 watch be used for the day watch and a 6&6 for the night watch.

The Department of Fisheries and Oceans/Canadian Coast Guard (DFO/CCG) is interested in extending crewing periods in Arctic icebreaking operations from 28 days to 42 days. Extended crewing periods are aimed at providing better service to Coast Guard clients by reducing the downtime for crew changes which affect client schedules. CCG would also realize a significant cost savings with fewer crew changes. As the data from the watch schedule comparison study completed in 1995 did not address how watchkeepers would perform under the extended 42-day crewing conditions, DFO/CCG realized that additional studies were required to determine the effects this would have on crew state and the level of risk to crew and vessel safety.

The objective of this project is to assess the impact of 28-day versus 42-day crewing periods on watchkeepers' levels of fatigue, alertness, sleep, cognitive performance, and socio-psychological well-being in Arctic icebreaking operations. The research methodology combines procedures identical to those employed by the previous watch schedule comparison study, with a protocol of additional tests designed to increase the scope and sensitivity of the data collection.

1.2 Fatigue and Human Performance in Marine Operations

Performance effects associated with sustained operations, fatigue, time of day, circadian rhythms, shift work, and skilled performance have been studied extensively. In a paper prepared for the CCG, Martin (1990) reviewed these areas of research with specific reference to Coast Guard operations. The following summary focuses on key issues addressed by Martin, as well as on more recent research which is directly relevant to this project including: circadian rhythms; circadian rhythms and sleep; circadian rhythms and performance; fatigue and performance; other behavioural, psychological and situational factors; and recent studies in the marine environment.

1.3 Circadian Rhythms

The human body follows a pattern of 24-hour cyclic fluctuations, or circadian rhythms, including body temperature, cardiac rate, urine catecholamine excretion, blood chemistry, and other physiological measures (D'Amico *et al.*, 1986). These rhythms are entrained by environmental stimuli such as light/dark, temperature fluctuations as well as by one's awareness of time, and social/domestic activities including planned meals and other regularly scheduled protocols (Naitoh, 1982).

Night workers who remain on fixed schedules often experience a complete phase shift in both physiological and related performance cycles as an adaptive response to their heightened level of activity at night and pattern of sleep during the day. This type of adaptive response generally takes two to three weeks to stabilize (Akerstedt *et al.*, 1977; Knauth and Rutenfranz, 1976). On the other hand, individuals who work rotating shifts tend to develop free running circadian cycles which are unable to properly shift in phase because of continuously changing work schedules. This type of situation, termed disentrainment of the circadian rhythm, is experienced frequently in marine watchkeeping environments (Folkard *et al.*, 1993) and has the potential for the development of significant levels of cumulative stress.

1.4 Circadian Rhythms and Sleep

Although an individual on a regular night shift is capable of developing an out-of-phase circadian rhythm, in many cases the schedule of night workers is interrupted by interaction with day workers. This may occur through living and social situations with family and friends. As a result, it can be difficult for the wake/sleep cycle of an individual working on the night shift to totally adapt to a pure night routine. Studies have shown that night shift workers often obtain less sleep, have slower reaction times and have more variable psychomotor performance compared to day shift workers (Keran *et al.*, 1991).

One method used to assess sleep duration and quality involves using an actigraph to assess body movement. This is a non-invasive method utilizing an ambulatory monitoring system in the form of a wrist-watch device (Brooks *et al.*, 1988). Another is to use an innovative product called the NightCap, which provides a non-invasive measure of eyelid tremor (Stickgold *et al.*, 1995). Both of these instruments are used in the present study to collect data on sleep duration, sleep latency, and sleep efficiency.

For sleep to be effective it must take place during the appropriate point of the circadian cycle. This could be a normal day cycle or a phase shifted night cycle. It has been argued that the timing of sleep within the circadian cycle may be more important than the overall amount of sleep (Taub and Berger, 1974). When studying shiftwork, it can be useful to monitor circadian rhythms to determine if in fact sleep is occurring at an optimal point.

Fragmented sleep, which frequently results during marine watches, also leads to less effective rest and in some instances bimodal rhythms. Rutenfranz *et al.,* (1988) showed that one sleep period, in which the onset was before midnight, was subjectively rated to be of better quality than sleep of equal length that was divided into two periods and that began during the day. Bearne (1981) also showed that fragmented sleep is less effective for recovering from sleep loss. Taub and Berger (1976) indicate that watchkeeping schedules are typically associated with acute sleep reduction.

1.5 Circadian Rhythms and Performance

Circadian rhythms of physiological indices are correlated with cycles in performance. Measures such as melatonin concentration (a hormone related to sleep) in urine as well as body temperature have been widely used to track circadian cycles and the relationship between physiological state and performance. For rhythms which are entrained to a day cycle, body temperature follows a pattern in which the low point is between 0200h and 0600h. Subsequently, temperature rises steeply throughout the morning until noon and rises less rapidly until 1600h to 2000h. At this time, temperature decreases gradually to its low point during the early hours of the morning (Aschoff, 1980).

Fluctuations in body temperature have been positively correlated with specific aspects of performance including: signal detection; reaction time; alertness; neuromuscular coordination; mathematical processing; and attention (Kleitman and Jackson, 1950; Colquhoun *et al.*, 1968a, 1968b). However, a number of studies caution against the use of body temperature as an index of efficiency, especially when subjects are experiencing changes in their normal schedules (Klein and Wegmann, 1979; Wilkinson, 1982). Thus, performance measures, rather than physiological indices, are recommended to assess levels of efficiency and quality of work under these types of conditions (Wilkinson, 1982).

Assuming a normal circadian cycle, performance from approximately 0200h to 0600h will be seriously impaired, regardless of how much sleep an individual has received. Daily performance fluctuations have been observed for specific tasks. Perceptual-motor ability increases over the day, while memory tasks peak early in the morning and decline subsequently (Colquhoun, 1985). Folkard and Monk (1979) noted that because different cognitive functions peak at different times, a particular shift work system might capitalize on one type of performance but not another.

A recent literature review looking at accidents and injuries as a function of time of day has shown that the period from 0100h to 0700h is of particular concern (Smith *et al.*, 1995). MacDonald *et al.* (1995) also found that the first few hours on shift are highly correlated with decreases in performance, an effect which may be linked to a phenomenon termed "sleep inertia". These points in time, when shift workers are particularly vulnerable to performance disruptions, are currently called "zones of extra vulnerability" (Smith *et al.*, 1995).

1.6 Fatigue and Performance

Two types of fatigue which are identified in the literature are acute and cumulative. Acute fatigue results from short duration, intense skill demanding activities. Cumulative fatigue occurs over a period of successive days or weeks and is the result of insufficient sleep recovery time. Given the demands of watchkeeping cycles, there is the potential for both acute and cumulative fatigue.

Shearer (1989) noted that when fatigued, individuals tend to relax performance criteria (e.g., speed/accuracy operating characteristics) and that they become satisfied with less than adequate levels of accomplishment. This is often associated with explicit decreases in performance speed, increases in error rates, and increases in risk taking behavior. Cognitive decrements associated with fatigue also appear to involve two distinct types of deficits, namely errors of commission and errors of omission. These effects are associated with disturbances to performance control mechanisms and blocking, or what is frequently termed micro sleeps. This explains the sensitivity and importance of using signal detection measures in assessing fatigue (Wilkinson *et al.*, 1966).

Attention, motivation, vigilance and concentration all decline with fatigue and an individual is more susceptible to distractions. Pascoe *et al.* (1995) suggested that performance problems may be more closely related to requirements to remain alert and active rather than to those posed by workload itself. Fatigue effects also appear to be cumulative. On reaching threshold, fatigue frequently causes an abrupt decline or disruption in performance. The length of time to produce this type of disturbance appears dependent on characteristics of the task, environment and characteristics of the particular individual (Ellingstad *et al.*, 1970). In a study on sleep deprivation, Heslegrave (1994) demonstrated that fatigue-induced performance deterioration was accompanied by greater task-related increases in heart rate. This suggests that greater physiological effort is required to maintain levels of performance while fatigued. Depending upon the severity of the fatigue, this may or may not be sufficient to prevent performance impairment.

1.6.1 Compensatory Effects

For relatively short periods of time, individuals can draw on inner resources, including motivation, to overcome the effects of fatigue on performance (Johnson and Naitoh, 1974). However, this type of compensatory response occurs at a physiological cost, which has the potential to accumulate over sustained periods of operation. These effects may be of particular concern with an aging work force (Heslegrave *et al.*, 1995), as well as with the need to meet additional work demands and deal with novel situations including unforeseen emergencies (Hartmann and Cantrell, 1976; Shearer, 1989; Federico, 1995). The possibility of compensatory performance effects of this type can be investigated by looking at performance variability and by using measures of vigilance and subjective workload to determine residual processing capacity (D'Amico *et al.*, 1986). In addition, subjective assessments of performance are known to be particularly sensitive to fatigue (Johnson and Naitoh, 1974).

1.6.2 Task Demands

Task demands influence arousal and fatigue. Accepted models of arousal and performance suggest that optimal levels of arousal or internal activation exist for different types of tasks. Monotonous routine tasks such as looking for infrequent, unexpected targets and monitoring displays, as is the case with many watchkeeping activities, rapidly lead to lower arousal levels (Donderi and Smiley, 1990). Low arousal levels are characterized by lapses in attention, increased reaction time, diminished memory and failure to complete procedures (Bohnen and Gaillard, 1994). When combined with fatigue, tasks of this type pose a particular concern to performance and safety. Performance feedback can help mitigate these effects, but the overall potential for catastrophic failure rises significantly when arousal levels dip below a critical level. This relationship between task demands and arousal levels emphasizes the importance of identifying task characteristics by means of a task analysis (including duration and time of day) in conjunction with levels of fatigue. This is particularly important in terms of establishing optimal work schedules and task design.

Aspects of performance affected by fatigue which are of concern to marine operations are long duration tasks that are externally paced, complex, and that require high levels of attention, memory and vigilance. Newly learned tasks and responses to novel situations as well as situations requiring insightful solutions are also particularly sensitive. According to Naitoh *et al.*, (1969), some specific tests which are sensitive to fatigue include: addition speed; auditory and visual vigilance; reaction time; memory; and tracking.

1.7 Other Behavioural, Psychological, and Situational Factors

Fatigue affects many aspects of behaviour including mood and subjective assessments of stress. In a U.S. Department of Transport study, dimensions of mood which were relevant to fatigue and operational issues included: withdrawal; irritability; and level of confidence (Colquhoun *et al.*, 1968a, 1968b). Effects on mood are of concern because of their potential to influence levels of motivation relative to task performance. Mood changes also affect socio-psychological well-being which can affect interaction between crew members, crew dynamics, team cohesion, and overall effectiveness of the vessel (Stretch and Jameison 1990; Josavai and Heslegrave, 1991).

Other psychological factors which have the potential to interact with fatigue effects include level of interest, motivation, and personality variables. Level of interest and motivation improve the level of arousal, and are capable of increasing or decreasing performance deficits associated with circadian rhythms and sustained operations (Johnson and Naitoh, 1974). With highly motivated individuals, certain performance deficits may be improved, while low levels of motivation or boredom have the potential to cause additional performance degradation. One's willingness or motivation to restructure a work cycle has been recognized as the most important single determinant of overall performance (Naitoh, 1982).

The relationship between personality and fatigue during sustained operations is also important. For example, introverts are thought to be less affected by environmental stress and sleep loss than extroverts, due to their internal locus of control. Introverts tend to be less influenced by external factors in the work environment (Johnson and Naitoh, 1974). Individuals may also be classified as either morning or evening types. Evening types tend to be more extroverted than morning types (Folkard, Monk and Lobban, 1979) and exhibit circadian cycles which usually peak later in the day. Furthermore, personality variables have been linked to the ability to sleep at unusual times of the day (Folkard Monk and Lobban, 1979). In a report for the European shipping community it was recommended that one of the selection criteria for watchkeepers should be personality temperament (Lowe *et al.*, 1987). The possibility of morning types differing from evening types, in terms of their ability to perform specific kinds of tasks at different times of days, may also be relevant to sustained operations on CCG vessels (Horne and Osterberg, 1976).

Other factors which have the potential to modify the level of fatigue include: physical exercise; noise; temperature; alcohol; caffeine; drugs; and breathing atmosphere. Although some of these factors may behave as stimulants that decrease the effects of low levels of arousal, their effects are short lived. Recovery from this type of stimulation is taxing to the individual and becomes an additional source of stress. This may further compound fatigue and related decrements in task performance. For example, noise on CCG vessels related to vessel operation and environmental factors such as icebreaking is of particular concern because of its fatigue generating effects and potential to interact with sleep deprivation.

1.8 Recent Studies in the Marine Environment

A review of the physiological and psychological impact of various work-rest schedules was completed recently for the CCG (Martin, 1990). It was noted that long, work-paced complex tasks which required high attention, vigilance, but which lacked performance feedback showed a high sensitivity to total sleep loss. Tasks requiring both short- and long-term memory, visual vigilance, visual tracking or newly acquired skills were also sensitive to sleep loss. Martin indicated that these findings have serious implications for the marine environment and that these task demands closely resemble watchkeeping activities.

Because of the relationship between task demand and performance, particularly in the context of fatigue and sustained operations, Lowe *et al.* (1987) recommend examining the activity of the vessel and the tasks on particular watches to determine the ideal schedule for the watchkeepers. On the basis of operational and task requirements, 6&6 watches were recommended for coastal missions, and 12&12 for deck watches and unloading in ports.

As a further example of the relationship between operational requirements in relation to the selection of watchkeeping schedules, the Western Region CCG has adopted a 12&12 schedule because vessels are usually active only during daylight hours. At night, the vessels are generally at anchor, thereby reducing activity for the night watch. In terms of cognitive tasks and performance requirements, this system allows circadian rhythm cycles to be synchronized. Night watch personnel usually are not required to sustain high performance levels for the entire watch and both watches benefit from good environmental conditions for sleeping. Moreover, both watches have more than adequate sleep time (Donderi *et al.*, 1995).

The watch schedule comparison study also examined performance over a 28-day crewing period for crew who were on 6&6 compared to 4&8 watch schedules. Although the 4&8 schedule allowed for longer periods of uninterrupted sleep, and the literature suggests that the 6&6 schedule should be more fatiguing, no operationally significant performance, mood or sleep differences were reported in the two watch schedules. Thus, one schedule was not recommended over the other; however, recommendations were made for implementing a modified 4&8 for the day watch and a 6&6 for the night watch (Donderi *et al.*, 1995).

Typical field study limitations were confronted in the latter study, including variations in sample size across conditions, short durations for administering tests, and the influence of extraneous variables. One issue of particular concern, however, was the amount of sleep that the crew obtained. Although significantly longer sleep was reported for personnel on the 4&8 watch, both the 4&8 and 6&6 were sleep restricted. Some indication of poorer sleep quality was also reported. The likelihood that both watches experienced sleep deprivation underlines the importance of looking at sleep characteristics more thoroughly.

1.9 Report Layout

This report is structured as follows:

- Section 1: Introduction
- Section 2: Experimental Methodology
- Section 3: Results and Discussion
- Section 4: Summary
- Section 5: Recommendations
- Section 6: Limitations of the Study
- Section 7: References
- Section 8: Appendices

Appendix A: Work Plan: Study on Extended Crewing Periods
Appendix B: Differences between the 28- and 42-Day Crewing Periods
Appendix C: Differences between 4&8 and 12&12 Watches
Appendix D: Differences between Day and Night Watches
Appendix E: The Impact of 8 versus 15 days of Icebreaking
Appendix F: The Impact of Icebreaking Early Compared to Late in the Crewing Cycle
Appendix G: Body Temperature Shifts for Night Workers
Appendix H: FAIS Analysis of Vessel
Appendix I: Task Analysis of Bridge and Engineering Watchkeepers
Appendix J: Coping Strategies for Watch Personnel

2 EXPERIMENTAL METHODOLOGY

2.1 Ships

During the summer of 1996 two CCG Icebreakers (the Sir Wilfrid Laurier and the Pierre Radisson) participated in a study examining the effects of extended crewing periods on crew state. The Laurier was assigned to the Western Arctic and the Radisson to the Eastern Arctic. Data were collected from the Laurier during two 28-day crewing periods (31 July to 27 August, and 28 August to 24 September) and from the Radisson during two 42-day crewing periods (12 July to 18 August, and 20 August to 30 September).

2.1.1 Sir Wilfrid Laurier

The Laurier had a total crew complement of 30 (including the helicopter pilot, the flight engineer, and the ice observer) during both crewing periods. The Laurier engine room had a 2-man watch. The Chief Engineer and Senior Engineer were on a day worker watch (Table 2.1), while one engineer and one oiler were on each watchkeeping schedule. The Laurier Bridge also had a 2-man watch. The Captain and Chief Officer were on a day worker watch, and one officer of the watch and one helmsman were on each watchkeeping schedule.

2.1.2 Pierre Radisson

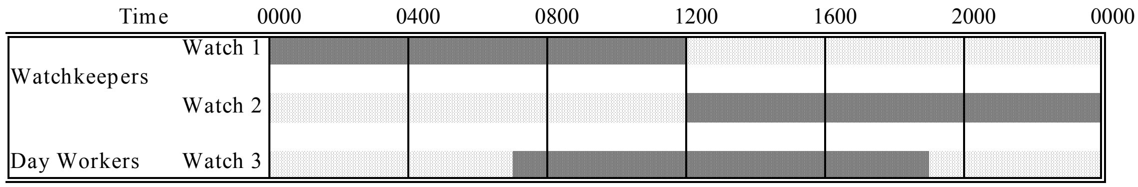
The Radisson had a total crew complement of 41 (including the helicopter pilot, the flight engineer, and the ice observer) during both crewing periods. The Radisson engine room had a 3-man watch. The Chief Engineer and Senior Engineer were on a day worker watch and two engineers and two oilers were on each watchkeeping schedule. The Radisson bridge also had a 3-man watch. The Captain and Chief Officer were on a day worker watch and two officers were on each watchkeeping schedule.

2.1.3 Watchkeeping schedules

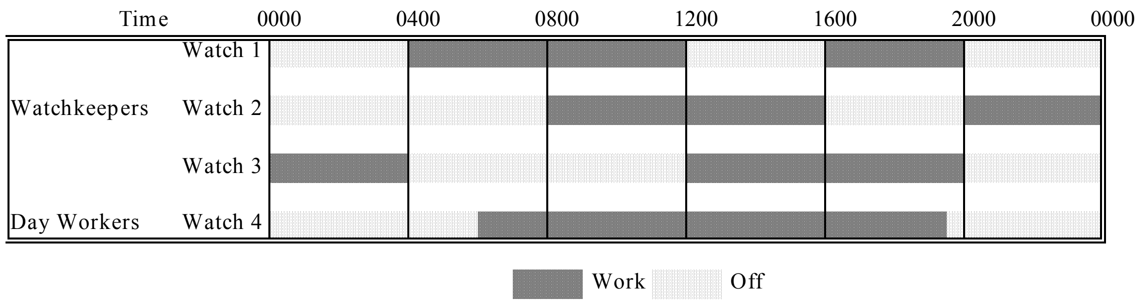
The watchkeeping schedule on the Laurier was 12 hours on and 12 hours off (12&12), with watch rotations taking place at 12:00 and 24:00. The watchkeeping schedule on the Radisson was 4 hours on, 8 hours off, followed by 8 hours on and 4 hours off (4&8). Watchkeepers on the Radisson were on watch for an additional half hour as meal times were not included in the watchkeeping schedule. On the Radisson there were three 4&8 watches which started at 16:00, 20:00, and 24:00. Watchkeeping and day worker schedules for each vessel are shown in Table 2.1.

Table 2.1:
Watch rotation schedules for the Laurier and Radisson.

Laurier



Radisson



2.2 Crew

Thirty-two watchkeeping crew between 20 and 60 years of age participated in this study. Fourteen (1 female and 13 males) were bridge watchkeepers and 18 (2 females and 16 males) were engineering watchkeepers. In addition, 32 deck crew on day work (9 females and 23 males) participated in some parts of the study. Details on the number of watchkeepers and day workers who participated from both vessels are provided in Table 2.2.

Table 2.2:
Summary of crew members from the Laurier and Radisson who participated in the study.

	Laurier	**Radisson**
Bridge Watchkeepers	5 (1 female)	9 (0 females)
Engineering Watchkeepers	7 (0 females)	11 (2 females)
Day Workers	22 (7 females)	10 (2 females)

2.3 Procedures

A detailed description of each measure used in this study is provided in the Work Plan dated June 1996 (Appendix A). The proposed work plan was approved by the Simon Fraser University Ethics Committee. In accordance with current research ethic standards, participants signed an informed consent document explaining the purpose and experimental protocol for the study. Crew were informed that all data would be kept confidential and that information would be provided to CCG only in summary form, making it impossible to identify the responses of any individual.

Data were obtained on cognitive performance, sleep, fatigue, and socio-psychological well-being. Supplementary information was obtained on the use of medication and on psychophysiological symptoms experienced before and after watches.

2.3.1 Participants

Participants were CCG crew assigned to Arctic icebreakers. In the original work plan (Appendix A), data collection focused on watchkeepers on the bridge and in engine room. From the outset, it was recognized that this would provide a limited number of subjects (approximately six per vessel) which would restrict the statistical power of the study. In order to have a more robust design, it was recommended that other bridge and engine room crew working on other watch schedules be encouraged to participate in order to provide ten "watch personnel" subjects per vessel. Because there was no certainty that enough watchkeepers would participate in the study, day workers were also encouraged to participate in some of the measures. For example, some of the dayworkers on the Radisson worked a 12&12 watch. The original intention was to merge their data with data from watchkeepers and other watch personnel.

An outline of the original experimental schedule, including measures and participants, is provided in Table 2.3. Due to logistical constraints which were imposed by data collection in the field environment, some of the data could not be combined as initially planned. The modified schedule of data collection and personnel who participated in each measure is outlined in Section 2.4.

Table 2.3:
Summary of recommended data collection periods including measures and participants.

	Participants
Before, After and During Watch	
Subjective Performance Assessment Questionnaire	Watchkeepers
DELTA Test Battery	Watchkeepers
Situational Awareness Questionnaire	Watchkeepers
Subjective Workload Assessment	Watchkeepers
Commanding Officer Assessment of Crew Fatigue	Commanding Officer
Mood Assessment Questionnaire	Watchkeepers
Once per Day	
Sleep/Activity Log	All
Biweekly	
Group Dynamics and Team Cohesion Questionnaire	All
Mood Assessment Questionnaire	All
Ongoing Collection	
PAM2/Actigraph	Watchkeepers
Body temperature (tympanic)	Watchkeepers
Only When BCRI On-Board	
Oculometry (NightCap)	Watchkeepers
Task analysis	Watchkeepers
Ship activity log	
One-Time-Only Measures	
General History Questionnaire	All
Personality Inventory	All
Medication Information Questionnaire	All
Subjective assessment of noise, lighting and temperature	All

2.3.2 Measures

Cognitive

Cognitive performance was assessed using three measures. The first was a computerized test battery called "Delta-WP" (Essex, 1992), a human performance and measurement system containing 6 standard cognitive tests measuring various aspects of cognition, perceptual ability and psychomotor performance. The second was a subjective assessment of situational awareness, and the third was a subjective workload assessment using a modified version of the NASA Task Load Index (TLX). The modification to the NASA TLX was the addition of a separate workload scale to assess visual effort.

The Delta test battery included measures of short-term memory, grammatical reasoning (Laurier only), mathematical processing, successive pattern comparison, spatial processing and choice reaction time. Grammatical reasoning was excluded from the Radisson because of difficulties translating this test into French.

Measures of response time and accuracy were obtained with the Delta tests. In addition, failure rates (instances where crew were unable to meet a preset minimum criterion test score and were required to repeat the test) were examined.

Sleep

Sleep was assessed using four methods. The first two were objective techniques using a wrist-mounted activity monitor (PAM/2) and a portable sleep monitoring system (NightCap). The PAM/2 was worn on the dominant hand of the participant for the entire time aboard the vessel. The NightCap was worn by participants during their main sleep. Because of the novelty of the instrument, the study was designed so that the NightCap was worn by participants every night that an experimenter was on board. This represented critical times during the sailing, including the initial few days, the period around 28 days, and the last week of the 42-day sailing. The main sleep for crew on a 4&8 schedule was after their eight-hour watch.

The remaining two measures of sleep were subjective ratings of sleep duration and sleep quality. These were recorded on a daily basis by means of sleep/activity logs filled out by each participating crew member upon waking after their main sleep.

The PAM/2 activity monitor provided an objective measure of sleep duration while the NightCap provided data on both sleep duration and sleep quality. The NightCap quantified sleep quality in terms of sleep latency (time to fall asleep) and sleep efficiency (the ratio of total sleep to the time in bed).

Information on sleep duration presented in this report is based on objective data from the PAM/2 or NightCap, where available, and from the sleep activity log if objective data were not available. If a participating crew member did not wear the PAM/2 or NightCap while sleeping, objective data were not available.

In addition to measuring sleep, attempts were made to record body temperature at regular intervals to examine possible changes in circadian rhythms associated with working night watches. Core body temperature was measured at the tympanic membrane in the ear using a tympanic thermometer.

Fatigue

Crew fatigue was assessed daily using three measures. The first two required the Commanding Officer (CO) and Chief Engineer (CE) to provide subjective assessments of overall crew fatigue and levels of workload. For these measures, the CO assessed the entire crew while the CE's assessments were restricted to the engineering crew only. The third measure of fatigue was a self-assessment of task and mental performance made by individual crew members at the end of their watches.

Socio-Psychological Well-Being

Socio-psychological well-being was assessed using two methods. The first was a subjective assessment of mood using six scales (alertness, cheerfulness, calmness, irritability, confidence, and withdrawal). The second was a measure of group dynamics, morale, and response to stress.

Additional Measures

Additional information collected throughout the crewing cycles included frequency of using daily medication, and symptoms experienced before and after watches. Symptoms investigated were: general discomfort; stomach awareness; headaches; yawning; physical fatigue; drowsiness; apathy; tension/anxiety; dizziness; and steadiness. Examination of the steadiness data suggested that this symptom was likely misinterpreted throughout the study. In some instances crew interpreted a high value on the steadiness scale as indicating increased steadiness and in other instances the reverse was true. For this reason, steadiness has been excluded from the analyses.

Fleet Activity Information System (FAIS)

The Fleet Activity Information System (FAIS) is a procedure used by CCG to monitor vessel activity and workload. FAIS data were analyzed to determine if the level of ship activity in 1996 was similar to the previous year (Appendix H). Data were grouped into categories based on their FAIS code. The proportion of time spent in each activity was calculated as a function of total chronological time. These proportions were derived by dividing the number of hours logged for a given activity by the total chronological hours.

The categories used in the FAIS analysis were:

- temporarily idle;
- fixed short range aids;
- floating short range aids;
- icebreaking operations;
- SAR;
- non-SAR vessel readiness;
- SAR vessel readiness;
- total vessel readiness;
- transit in ice;
- transit out of ice;
- total transit;
- maintenance;
- delays; and
- other.

2.4 Analysis

2.4.1 Grouping of Crew

Table 2.4 shows the schedule of data collection and groups who participated for each measure in this study. Although data were collected from other watch personnel and day workers, the focus of this study was on watchkeepers. For the purpose of data analysis, crew were divided into three groups, depending upon their level of participation and job title.

Group 1: watchkeepers who participated daily on all measures;

Group 2: watchkeepers and day workers who participated on select measures which were recorded only at the beginning, middle and end of the crewing periods; and

Group 3: day workers who completed the same daily measures as Group 1, with the exception of an objective measure of sleep (i.e., NightCap).

Due to constraints which were imposed by data collection in the field environment, data from Group 2 were insufficient to assess the effects of the crewing period on performance measures. Hence, data from Groups 1 and 3 are the focus of this report.

Table 2.4:
Summary of data collection procedures.

Experimental Parameter	Measures	Schedules of Data Collection	Participating Groups
Cognitive	• DELTA performance battery: short-term memory; grammatical reasoning (Laurier only); mathematical processing; spatial processing; pattern comparison; and choice reaction time	Pre- and post-watch (mid-watch for night watch only)	Groups 1 and 3
	• Situational awareness questionnaire	Pre- and post-watch	Groups 1, 2* and 3
	• Subjective workload assessment	Post-watch	Groups 1 and 3
Sleep	• Activity monitor (PAM/2)	24 hours per day	Groups 1 and 3
	• Sleep assessment (NightCap)	While sleeping, during weeks 1, 4, and 6 of the sailing	Group 1
	• Sleep/activity log	Once per day	Groups 1 and 3
	• Circadian rhythms-body temperature (tympanic)	Every 4 hours starting at the beginning of watch	Groups 1 and 3
Fatigue	• Subjective assessment of performance	Post-watch	Groups 1 and 3
	• Commanding officer and Chief engineer assessment of crew fatigue and workload	Once per day	Commanding officer and Chief engineer
Socio-psychological well-being	• Mood assessment questionnaire (alertness, cheerfulness, calmness, irritability, confidence, withdrawal)	Pre- and post-watch and mid-watch (night watch only)	Groups 1, 2* and 3
	• Group dynamics, morale, and response to stress	Beginning, middle and end of crewing period	Groups 1, 2* and 3
Additional	• Frequency of using daily medication	Once per day, pre-watch	Groups 1 and 3
	• Symptoms experienced before and after watch (general discomfort, stomach awareness, headaches, yawning, physical fatigue, drowsiness, apathy, tension/anxiety, dizziness, steadiness).	Pre- and post-watch	Groups 1 and 3

* **Note:** Group 2 completed the mood assessment and situational awareness measures only at the beginning, middle and end of the crewing periods.

2.4.2 Data Analysis

Data were examined in relation to the following key issues:

- differences between the 28- and 42-day crewing periods;
- differences between 4&8 and 12&12 watches;
- differences between day and night watches;
- the impact of 8 versus 15 days of icebreaking;
- the impact of icebreaking early as opposed to late in the crewing cycle;
- body temperature shifts for night workers (representing physiological adaptation to night watchkeeping).

Because of small or incomplete data sets and a limited number of watchkeepers on any particular watch, this approach was adopted rather than the more traditional approach which requires a fully balanced experimental design with independent samples. In many instances, for example, the analysis examined effects from very few subjects, which also raises the issue that an individual's data could bias the overall findings.

Results are presented and discussed in Sections 3.1 to 3.7. Data tables for each of the issues are presented in Appendices B through H.

Analysis of the Differences between the 28- and 42-Day Crewing Periods

Data were initially compared between the two 28-day crewing periods on the Laurier and the first 28 days from each of the two 42-day crewing periods on the Radisson. Because there were no significant differences observed for any of the measures between the two vessels, data from the four 28 day periods were pooled. This procedure provided a more stable estimate against which to compare the changes observed between days 29 to 42 on the Radisson. Subsequent comparisons were based on data averaged weekly for weeks 2 to 4 (Laurier) and weeks 4 to 6 (Radisson).

During its first sailing, the Radisson did not leave port until the fifth day of the crewing period, at which time data collection was initiated. Therefore, the first day of data collection for this sailing was compared to the fifth day for other crewing periods. This ensured proper comparison of measures such as mood and team cohesion which were expected to change in relation to time at sea.

Data from the Delta performance tests showed a learning effect in the initial period of data collection. To reduce the impact of the learning effect, the first week of Delta data were not examined. Data for the other measures were also excluded from comparisons for the first week to minimize variability associated with learning.

A repeated measures analysis of variance (ANOVA) was used to compare the measures for the 28-versus 42-day crewing periods. Where limited data were available, such as the CO's and CE's assessments of crew fatigue and workload, changes over weeks were expressed as percent differences.

Significant effects or trends are reported between weeks. Normally a series of pairwise comparisons would be used to identify the specific week(s) where change occurred. However because of the numerous pairwise comparisons that would be involved, the possibility of Type 1 errors (falsely finding an effect) would increase considerably. In this case the more appropriate procedure is careful inspection of the graphed data to identify the time of the effect.

Other Analyses

For issues other than the comparison of differences between the 28 and 42 day crewing periods, data for all crew (including day workers) were combined into appropriate groups (e.g., 4&8, 12&12, day, night, etc.). This decision was supported by the lack of difference observed between the Laurier and Radisson during the first 28 days of their respective crewing periods. Day workers (non-watchkeepers) were included in several of the analyses to increase sample size and statistical power. For each group, daily scores were averaged over relevant periods. Depending whether categorical or measurement data were collected, ANOVA, t-test and Chi-square procedures were employed to test for statistical significance. Scores were pooled for the cognitive performance tests administered before, during and after watch, because no pre- versus post-watch differences were found between these assessments on any of the issues addressed.

The key in this study was to examine results from all measures simultaneously, looking for consistent patterns of change or converging evidence. Significant effects were viewed as meaningful when they were consistent with patterns of change observed in other measures. Where sufficient data were available for statistical analysis, significant differences were reported when the probability of an effect, or difference was less than or equal to 0.05. Trends were reported when the probability of effect was less than or equal to 0.10. Because of limited data sets on some of the measures, such as the CO's and CE's assessments of fatigue, the Delta test failure rates and the NightCap, statistical analysis was not always possible.

3 RESULTS AND DISCUSSION

3.1 Differences between the 28- and 42-Day Crewing Periods

To determine if an extended crewing period affected crew performance or well-being, differences in crew state were examined between the 28- and 42-day crewing periods. Changes in crew state were assessed by measures of cognitive performance, sleep duration and quality, subjective assessment of fatigue or socio-psychological well-being. Other factors considered were frequency of use of medication and symptoms experienced before and after watches (general discomfort, stomach awareness, headaches, yawning, physical fatigue, drowsiness, apathy, tension/anxiety, dizziness, steadiness).

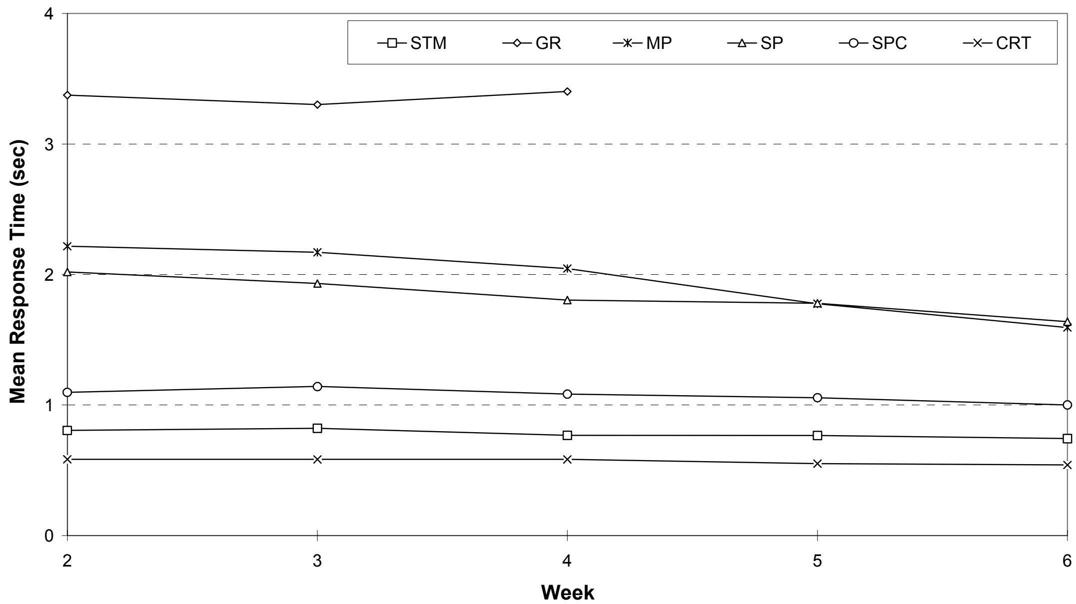
Data tables for this comparison are provided in Appendix B. Wherever possible, crew from the various watchkeeping schedules were pooled, with the critical variable being crewing period (i.e., 28 versus 42 days).

3.1.1 Cognitive Assessment

Performance

For any single day, no significant differences were observed on the Delta performance tests for the pre-, mid-, and post-watch assessments. Hence, these data were pooled for further analysis. The response time data, calculated as a weekly average for all Delta tests, are shown in Figure 3.1.

At the request of TDC, the Delta test results in this study were compared to those of other populations. As such data are not published in the literature, the manufacturer of the Delta battery (Essex Corporation) was contacted directly. At the time of contact, only limited data were available although Essex Corporation is in the process of compiling data from different populations for comparison purposes. The data provide by Essex are based on a study of college-age males and females, but no other demographic data were supplied. Of the data obtained from Essex, only three tests were common to the present study. These were grammatical reasoning (GR), spatial processing (SP), and choice reaction time (CRT). Table 3.1 illustrates the number of trials and the number of subjects in the study results obtained from Essex. The mean response times (Table 3.2) and the percent correct (Table 3.3) provide a comparison of data obtained in the Essex study to the present study.



STM = short term memory; GR = grammatical reasoning; MP = mathematical processing; CRT = choice reaction time; SPC = successive pattern comparison; SP = spatial processing.
* Significant effect on: MP, SP across weeks.

Figure 3.1:
Mean response time (sec.) on the computerized cognitive performance tests (Delta) for Group 1, as a function of weeks at sea.

Examination of the cognitive performance data across weeks (Table B-1) revealed significant effects for mathematical processing (MP) and spatial processing (SP), for both response time and accuracy. (Section 2.4.2 provides an explanation of the statistical treatment of the data). A trend was also observed for choice reaction time (CRT), which improved from 0.65 sec. in Week 1 to 0.54 sec. in Week 6. Because of the scale in Figure 3.1, this trend is not obvious. The effects on MP, SP, and CRT were all in the direction of performance improvement, suggesting that learning continued to occur throughout the 28- and 42- day crewing periods for each of the tests. No significant differences were observed for the remaining measures of cognitive performance (STM, GR, SPC).

Table 3.1:
Summary of the number of trials and number of subjects who participated in the Essex study.

Trial	1	2	3	4	5	6	7	8	9	10	11
n=	27	27	27	27	26	25	25	25	22	17	4

Table 3.2:
Mean response times obtained from crew on board icebreakers compared by week to data provided by the Essex Corporation.

Performance: Delta Mean Response Time (sec)

		Week 1		Week 2		Week 3		Week 4		Week 5		Week 6	
Test	Essex	G1	G3	G1	G3	G1	G3	G1	G3	G1	G3	G1	G3
GR	**3.04**	3.64		3.37		3.30		3.40					
SP	**1.38**	2.49	2.57	2.02	2.25	1.93	2.21	1.80	2.16	1.78	2.06	1.64	1.97
CRT	**.50**	0.65	0.69	0.58	0.66	0.58	0.63	0.58	0.67	.55	0.61	.54	.61

GR= grammatical reasoning; SP= spatial processing; CRT= choice reaction time; G1= Group 1; G3= Group 3.

Table 3.3:
Comparison of the mean percent correct obtained on the Delta performance test in the Essex study compared to the present study.

Performance: Delta Percent Correct

		Week 1		Week 2		Week 3		Week 4		Week 5		Week 6	
Test	Essex	G1	G3	G1	G3	G1	G3	G1	G3	G1	G3	G1	G3
GR	**76.9**	86.4		90.8		91.9		90.4					
SP	**85.5**	90.2	88.0	96.4	96.7	96.5	96.1	97.6	97.0	97.8	96.3	96.5	97.6
CRT	**99.7**	99.4	99.6	98.6	98.5	98.4	99.6	99.0	99.2	99.1	98.9	99.1	99.8

GR= grammatical reasoning; SP= spatial processing; CRT= choice reaction time; G1= Group 1; G3= Group 3.

While no statistical comparison of the data could be made, the mean response times of the participants in the Essex data appear to be better (i.e., faster) than in the current study. This may be due to the age difference in the two groups, since the age range of the present study was 20 to 60 years of age compared to college age in the Essex study. By comparison, participants in the present study appeared to be more accurate than in the Essex study. As seen in Table 3.3, a greater percent correct was observed in the present study for measures of grammatical reasoning and spatial processing. The percent correct on the choice reaction time measure appears to be very similar between the studies. Greater accuracy usually comes at reduced processing speed, possibly explaining the differences between the two groups on tests of grammatical reasoning and spatial processing. However, the important issue in this study is the change relative to initial performance observed over weeks at sea.

In the present study, a failure was recorded when a subject failed to reach a pre-set criterion score on the Delta test battery. The failure rates, as expressed by the mean percentage of failures, are illustrated in Figure 3.2. Week 6 is excluded because of insufficient data. Data for Group 1 (watchkeepers who participated in all daily measures on both vessels combined) are compared to the results obtained on each ship separately (Table B-2).

Examination of the separate vessels showed that failure rates were highest towards the end of the crewing period, and that the crew from the Radisson experienced consistently lower failure rates, regardless of time at sea. The increase in failure rate over weeks at sea may reflect compromises to crew state but these data were extremely limited, and therefore must be interpreted cautiously. The lower failure rates on the Radisson could have been due to the exclusion of what appeared to be the most difficult test (grammatical reasoning) from their test battery because of difficulty translating the test into French.

Overall, data from the cognitive performance tests indicated that response time and accuracy (as distinct from failure rate) continued to improve during the first four weeks. This finding suggests that any cumulative fatigue over this period was not enough to counteract the effects of learning. Although the data are limited, there is also some indication that failure rates increased on both vessels with time at sea.

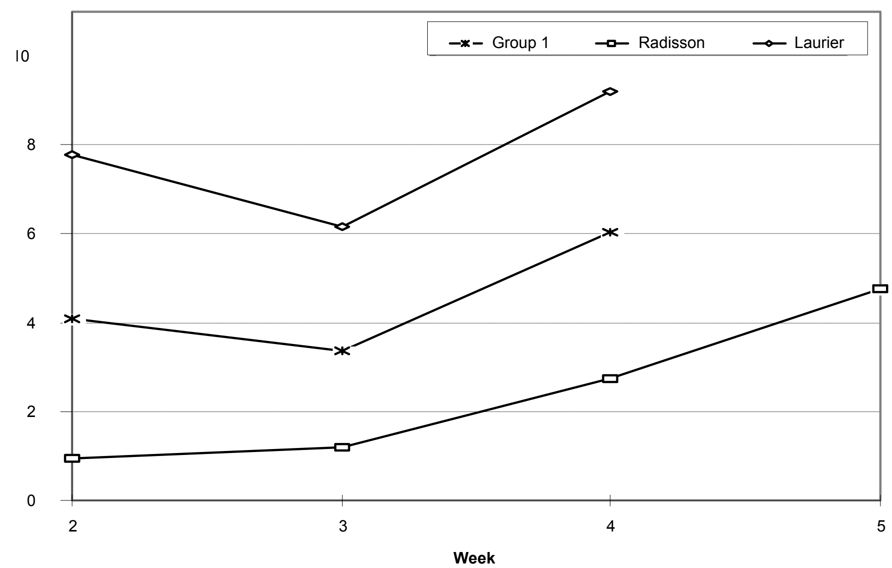


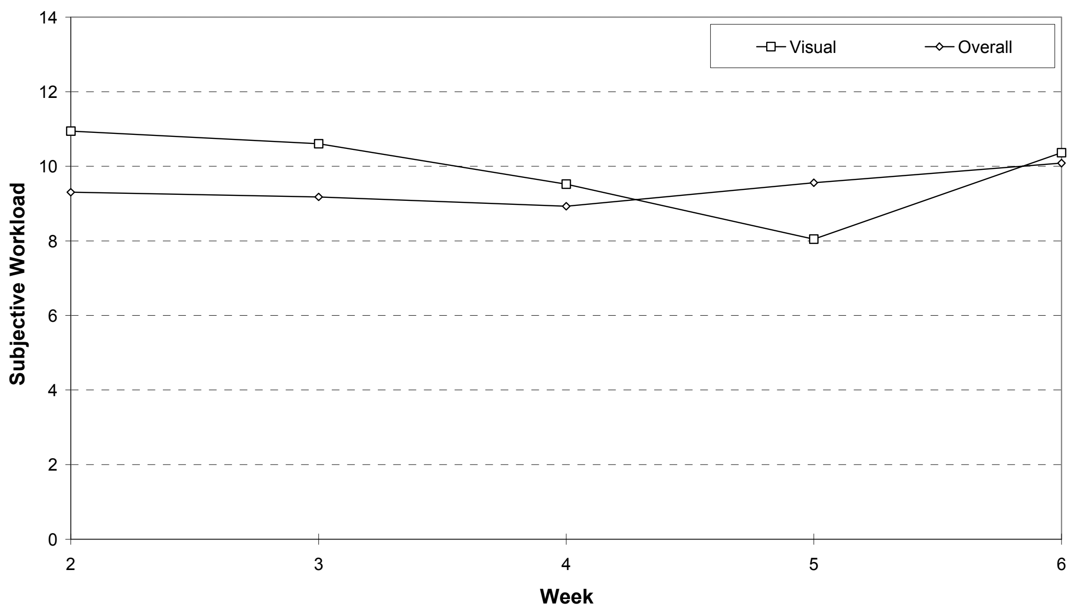
Figure 3.2:
Mean percentage of failures on the Delta tests as a function of weeks at sea (weeks two to five).

Situational Awareness

No significant differences or consistent patterns of change were observed for situational awareness between weeks 1 and 6 of the crewing cycles on either the pre- or post-watch assessments (Table B-3).

Subjective Workload

A significant decrease was observed for visual workloads which was most evident during week 5 (Figure 3.3; Table B-4). This is likely because the Radisson was docked at this time during one of its two sailings. Other dimensions of workload assessed by the NASA TLX (physical, mental, temporal, performance, effort, frustration, and relative workload) showed no significant changes. However, there were indications that frustration increased and that perception of subjective performance tended to decrease over weeks at sea (Figure 3.4). Relative workload was consistently rated as "no different than an average day".



* Significant effect on visual workload.

Figure 3.3:
Mean subjective workload ratings (NASA TLX) for Group 1 for visual and overall workload. The scale ranged from 1=low to 17=high.

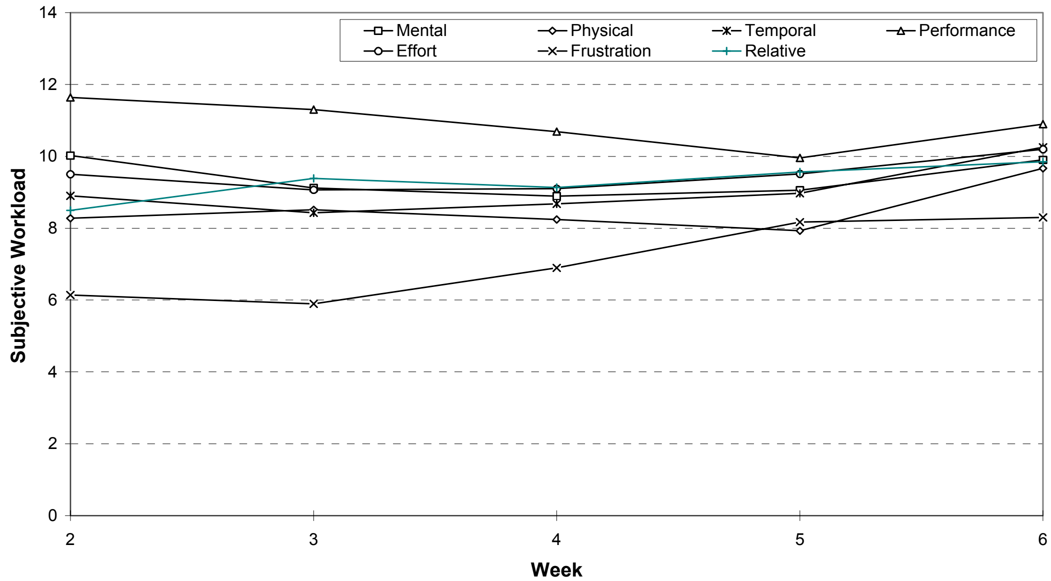


Figure 3.4:
Mean subjective workload ratings (NASA TLX) for Group 1. The scale ranged from 1=low to 17=high.

3.1.2 Sleep

The average sleep duration (minutes) over the crewing period is illustrated for Group 1 compared to the 12&12 and the 4&8 watch (Figure 3.5). During weeks 5 and 6, data for the 4&8 watch were from 8 and 7 participants respectively and data for the 12&12 watch were from 2 and 1 participants respectively. No significant differences were observed between the 28- and 42-day crewing periods, in terms of either sleep duration or sleep quality (where sleep latency was based on the time to fall asleep and sleep efficiency was the ratio of total sleep to the time in bed) based on data from the PAM/2 activity monitor, sleep/activity log and NightCap (Table B-5 and B-6). However, close examination of the data revealed a decrease in sleep from week 2 to 6 of approximately 50 minutes. This pattern was also apparent when data from the Radisson were examined separately. On the other hand, the subjective appraisal of sleep quality as "fair" or above was consistent over the entire period with a slight, though insignificant, improvement in sleep quality by week 6.

Overall the data suggest that sleep duration can decrease after week 4. Operationally, this is more important than the stable or minor improvement observed in sleep quality.

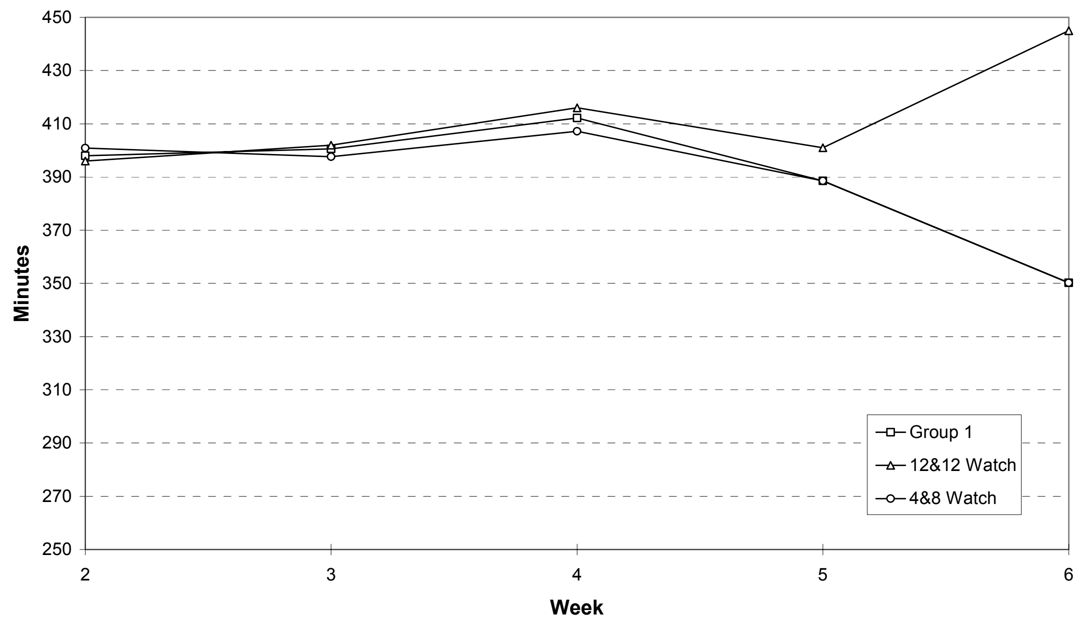


Figure 3.5:
Average sleep duration (minutes) over weeks 2 to 6.

3.1.3 Fatigue

Subjective Assessment of Task and Mental Performance

No significant differences were observed for self-assessment of task and mental performance between the 28- and 42-day crewing periods. This included difficulty with decisions, memory, simple tasks, concentration or apathy. Visual inspection of the data also showed no consistent pattern of changes in these symptoms (Table B-7 and B-8).

CO and CE Assessment of Crew Fatigue and Workload

The CO's and CE's assessment of crew fatigue and workload from are illustrated in Figure 3.6 and Table B-9. Throughout the crewing period, the CE's assessment of fatigue and workload appeared to be higher than the CO's. From weeks 4 to 6, the CO reported a steady increase in fatigue assessment of 24 percent without a large increase in workload. This may have been an early indication of crew fatigue in the absence of an increase in workload and could have implications on crew performance if workload were suddenly increased.

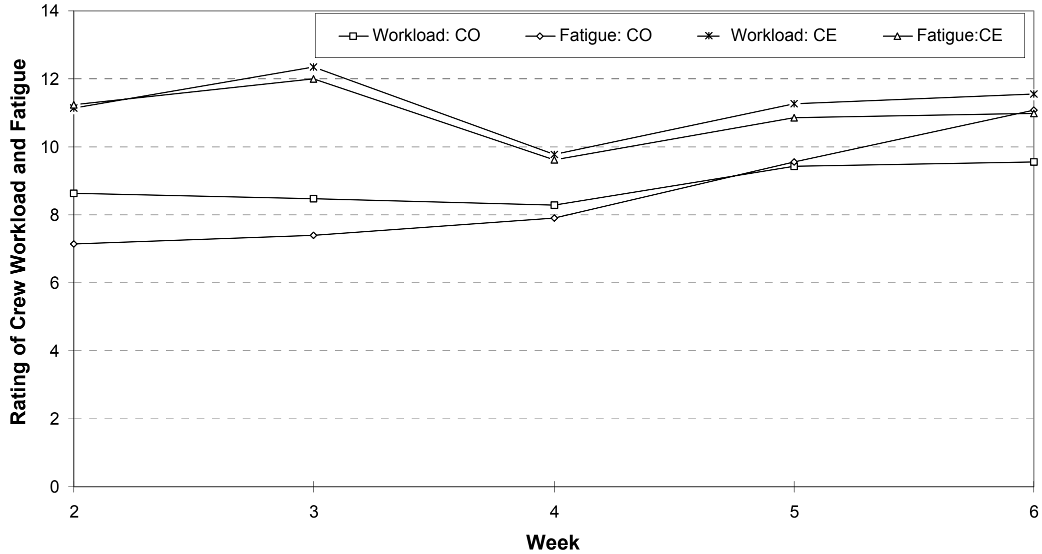


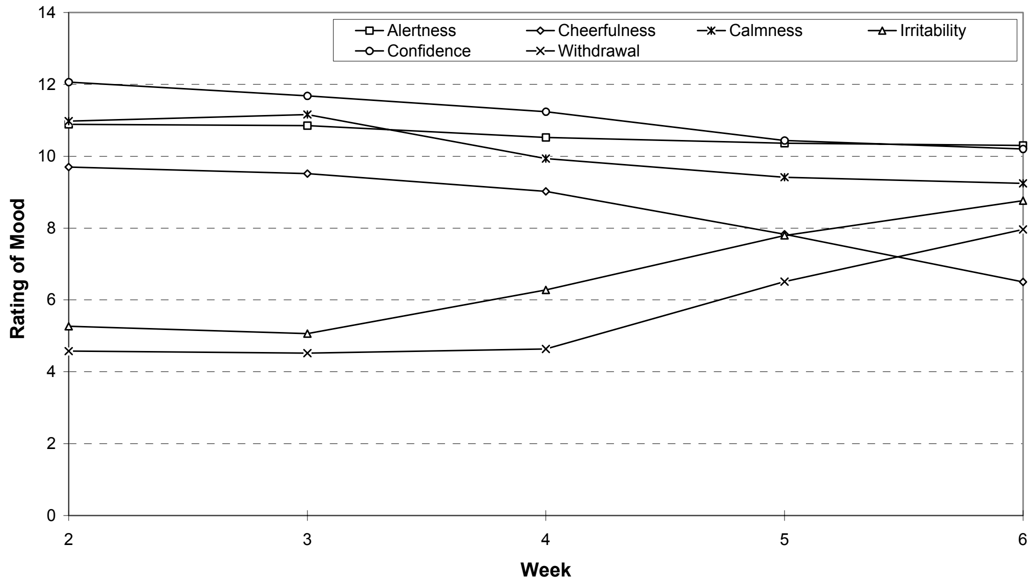
Figure 3.6:
Commanding Officer's (CO's) and Chief Engineer's (CE's) ratings of crew workload and fatigue for Group 1. The scale ranged from 1=low to 17=high.

3.1.4 Socio-Psychological Factors

Mood

Figure 3.7 illustrates the post-watch assessment of mood (including alertness, cheerfulness, calmness, irritability, confidence, and withdrawal) for the crew members in Group 1 from week 2 to week 6. Because a similar pattern was apparent on the pre-watch assessment, only post-watch data are illustrated (Table B-10 and B-11). On the pre-watch assessment there was a trend for less cheerfulness and calmness, and greater irritability in weeks 5 and 6. A significantly negative effect was observed for withdrawal for the post-watch assessment during weeks 5 and 6. Irritability also increased in the post-watch assessment from week 4 to 6.

Based on these changes, motivation to carry out tasks to their fullest potential and the quality of crew interaction may be in the initial stages of being compromised by the end of six weeks at sea. Effects of this type are precursors to changes in performance, and are of particular concern in non-routine situations, for example, with equipment malfunctions, SAR, and other marine emergencies.



* Significant effects on withdrawal.

Figure 3.7:
Post-watch mood ratings for Group 1. The scale ranged from 1=low to 17=high.

Group Dynamics, Morale, and Response to Stress

Significant effects were found on group dynamics and morale for items related to professional morale and leadership skills, with both items showing lower scores toward the end of the crewing period (Table B-12). There was also a trend for morale/cohesion to decrease after week 2. This may have implications similar to those for mood effects, possibly decreasing motivation to work, degrading the quality of crew interactions and ultimately influencing task performance. No clear pattern of effects was observed in crew response to stress.

3.1.5 Additional Measures

Frequency of Daily Medication

No differences were reported in the frequency of taking daily medication between the 28- and 42-day crewing periods (Table B-13).

Symptoms

Pre- and post-watch symptoms (including general discomfort, stomach awareness, headaches, yawning, physical fatigue, drowsiness, apathy, tension/anxiety, dizziness, steadiness) reported were generally very mild (Table B-14 and B-15). With the exception of a trend for apathy to increase pre-watch for Group 3 in week 5, no significant changes or consistent patterns of change were observed across weeks for the remaining symptoms.

3.1.6 Summary of the Differences between the 28- and 42-Day Crewing Periods

Effects on crew state between the 28- and 42-day crewing period were examined as changes across weeks. Negative effects on crew state were observed as an increase in workload, reduced sleep duration, lowered group dynamics, increased irritability, apathy, and withdrawal. These changes were most pronounced following week 4. Although the symptoms reported across weeks were generally very mild and showed little change, overall, the results of the 28/42 day comparison suggest that extended crewing periods may have a negative effect on crew state.

That no degradation in speed and accuracy was observed on the cognitive tests suggests participants were able to perform effectively for a limited duration. With relatively short cognitive tests, like the Delta measures which required approximately 90 seconds each to complete, participants were able to assign sufficient resources to prevent performance decrements. However, failure rates on the Delta tests increased on both vessels toward the end of the crewing periods suggesting early signs of a possible decrease in human performance. Longer, more sustained tests (i.e., vigilance tests) may be necessary to show objective performance decrements with extended crewing periods and different watch schedules. This may include measures such as signal detection tasks up to 30 minutes in duration, which would force crew to maintain sustained attention. Time constraints and crew availability made vigilance testing unacceptable during the current study.

Another approach may be to survey crew for changes in their performance strategies which could reflect cumulative fatigue. Changes in the way people perform their work (e.g., taking short cuts, altering task criteria, and shedding low priority tasks) are frequently observed during fatigue, without overt changes in task performance. The implication, however, is that performance capacity may be reduced and that unexpected or novel situations may pose problems. The development of fatigue becomes apparent on aspects of performance that are not highly overlearned. In vessel operations, this would include: diagnosis and repair of equipment failure; navigation under unusual or unfamiliar circumstances; search and rescue; and other marine emergency duties.

One parameter that may explain changes in crew state is reduced sleep duration. For example, during the last two weeks of the 42-day crewing period, there was a reduction in daily sleep of approximately 50 minutes per day (based on Activity Log and PAM/2 data). While this reduction would not be worrisome as a single occurrence, the buildup of sleep debt over the final two weeks may be a prime contributor to changes in crew state.

3.2 Differences between 4&8 and 12&12 Watches

The second issue which was examined was whether any differences in crew state were observed between the 4&8 and 12&12 watches, irrespective of the crewing period that they were on (i.e., 28 or 42 days). For example, some day workers on the Radisson were on a 12&12 watch. Data tables are provided in Appendix C.

3.2 1 Cognitive Assessment

Performance

Delta test data recorded for participants on the 4&8 watch schedule revealed a general pattern of superior performance compared to participants on the 12&12 watch (Table C-1). For example, a significant effect was observed on response time for mathematical processing which favoured the 4&8 watch. A trend in the data was also observed in accuracy of successive pattern comparison, again favouring the 4&8 watch. Although failure rates were higher for the 12&12 watch (Table C-2), this may be explained by the exclusion of grammatical reasoning from the test battery used on the Radisson (as discussed in Section 3.1.1). Personnel on the 4&8 watch schedule may also have been naturally better performers on these tests (as discussed in Section 3.2.6).

Situational Awareness

No significant differences were observed between the 4&8 and 12&12 watches for the pre- and post-watch assessment of situational awareness. Although the differences were not significant, in absolute terms situational awareness was slightly higher for the 4&8 during the post-watch assessment (Table C-3).

Subjective Workload

No significant differences were observed in subjective workload between the two watches. However, there was a trend for visual workload to be higher on the 12&12 watch. The 12&12 watch also reported slightly higher mental and physical workloads. While the 12&12 watch was exerting more mental and physical effort, they were also more satisfied with their performance than personnel on the 4&8 watch (Table C-4).

Lower visual workload reported by personnel on the 4&8 watch may have been due to the fact that during the second crewing period, the Radisson was stopped for almost three weeks. Frustration levels appeared to be higher for the 4&8.

3.2.2 Sleep

Sleep was monitored objectively using the NightCap and PAM/2 activity monitors, and subjectively by information taken from sleep/activity logs which were filled out by individual crew members. Data from the PAM/2 activity monitor and sleep/activity log showed no significant differences between the 4&8 and 12&12 watches in terms of sleep duration and sleep quality (Table C-5 and C-6). On the other hand, slightly higher sleep quality was observed with the 4&8 watch. The NightCap data showed that personnel on the 4&8 watch obtained significantly less sleep. This was likely related to the crew on the 4&8 only wearing the NightCap during their main daily sleep and not during their naps (some crew took naps during their four hours off). The NightCap data also showed a trend for personnel on the 4&8 watch to fall asleep faster than on the 12&12 watch. The 4&8 watch showed higher levels of sleep efficiency. However, this was not a significant effect.

Overall, this pattern of results suggests that personnel on the 4&8 watch schedule obtained less sleep than those on the 12&12 watch. However, differences appear to be slight at best and are based on a small numbers of subjects.

The results of this analysis appear to conflict with data from the 28/42 day comparison. In the present analysis there was no apparent difference in sleep duration between the 4&8 and 12&12 watches, whereas in the previous 28- and 42-day analysis there appeared to be a decrease in sleep duration in weeks 5 and 6 (which included personnel on the 4&8 watch only). Two factors which may contribute to the difference include:

- in the 28/42 day comparison, sleep duration data for weeks 2 to 4 were from all watchkeepers (i.e., both 4&8 and 12&12 watches), while sleep duration data for weeks 5 and 6 were from only 4&8 watchkeepers; and
- in the 4&8 and 12&12 analysis, sleep duration was averaged over weeks 2 to 6 for all watchkeepers for each week they participated.

Calculating weekly means in the 28/42-day comparison isolates the reductions in sleep duration, whereas reducing the data to a single average across all weeks, as in the 4&8 and 12&12 analysis, masks when reductions in sleep occur. As seen in Figure 3.5, watchkeepers on the 4&8 watch schedule had longer sleep durations during weeks 2 to 4 than weeks 5 and 6, but when weeks 2 to 6 are averaged together for all participants, the reduction in sleep duration in weeks 5 and 6 is masked.

3.2.3 Fatigue

Subjective Assessment of Task and Mental Performance

A significantly greater percentage of crew on the 4&8 watch schedule reported degraded task performance. A similar trend was observed for mental performance. However, no significant differences or patterns were observed in terms of difficulty with decisions, memory, simple tasks, concentration or apathy. The magnitude of the reported symptoms was small (less than 0.5 on a scale of 0 to 4) (Table C-7).

3.2.4 Socio-Psychological Factors

Mood

No significant effects were observed on mood between crew on the 12&12 compared to the 4&8 watch schedule. In the pre-watch assessment, however, there was a trend for crew on the 12&12 watch schedule to be more cheerful while the crew on the 4&8 watch schedule were more withdrawn. In the post-watch assessment there was also a trend for the crew on the 12&12 watch to be more cheerful and more confident while crew on the 4&8 watch schedule were more irritable. Overall, the data from the pre- and post-watch mood assessments suggest that mood was generally superior for crew on the 12&12 watch (Table C-8 and C-9).

Group Dynamics, Morale and Response to Stress

For group dynamics and morale, significant effects were observed on the items professional morale and leadership skills which favoured the 12&12 watch. A trend was also observed for morale overall, again in favour of personnel on the 12&12 watch. No significant effects were observed for response to stress but there was a trend for stress related to family separation to be greater with the 12&12 watch. This trend is likely group specific and not directly related to watch type. No other pattern of effects were observed for group dynamics, morale and response to stress (Table C-10).

3.2.5 Additional Measures

Frequency of Daily Medication

No significant differences were reported in the frequency of taking daily medication for personnel on the 4&8 and 12&12 watches, although a greater percentage of crew on the 4&8 were taking daily medication (Table C-11).

Symptoms

No significant differences or trends were observed in the report of pre- or post-watch symptoms between the 4&8 and 12&12 watches. Symptoms were reported as mild for general discomfort, stomach awareness, headaches, yawning, physical fatigue, drowsiness, apathy, tension/anxiety, dizziness, and steadiness (Table C-12 and C-13).

3.2.6 Summary of the Differences between 4&8 and 12&12 Watches

In comparing the 4&8 and 12&12 watch schedules, care should be taken when interpreting the results from the cognitive performance tests. As discussed in Section 3.1 and 3.2.1, failure rates on the Delta tests were lower for the Radisson crew, possibly because the grammatical reasoning task was excluded from their test battery. Failure rates were calculated for the entire test battery, and not for each individual test. However, crew on the 4&8 had higher scores from baseline and higher scores throughout compared to crew on the 12&12 watch schedule, suggesting the possibility that they were naturally better performers on the Delta tests.

The possibility that the crew on the Radisson's 4&8 watch were better performers in terms of speed and accuracy may not have been apparent in the initial comparison between ships in the 28/42-day analysis because of the way the crew data were pooled. For the 28/42-day analysis, the first 28 days from both sailings on the Laurier and Radisson were combined in order to increase statistical power. This pooling of data was possible because no between-vessel differences were observed for response time and accuracy, although a difference was seen on failure rate. Aboard the Radisson, both 12&12 day workers and 4&8 watchkeepers participated in the study, and the data from these participants were pooled in the 28/42 day analysis. This pooling of data (from 12&12 day workers and 4&8 watchkeepers) may have masked any possible difference between 12&12 versus 4&8 watch schedules based on the data used in the 28/42-day analysis.

Apart from the cognitive test scores and workload results, the measures of sleep duration, fatigue, mood, and group dynamics and morale suggest that the 12&12 watch was slightly superior in terms of crew state than the 4&8 watch, possibly making the 12&12 watch a more desirable rotation. However, due to the small changes which were observed and the lack of agreement between some of the measures, these findings require further confirmation.

3.2.7 Comparison of 4&8, 6&6, and 12&12 Watches

A previous study (Donderi, 1995) of the effect of 6&6 and 4&8 watch schedules on crew performance aboard CCG vessels was compared to the 12&12 and 4&8 watch schedules in the current study (Table 3.4).

Table 3.4:
Comparison of 6&6, 4&8, and 12&12 watch schedules on measures of sleep, alertness, and cognitive performance.

	Watch Schedule			
	Donderi et al. (1995)		BCRI, (1997)	
Variable	**6&6**	**4&8**	**12&12**	**4&8**
Total Sleep (min)	331.91	329.71	399.59	390.97
Sleep quality (% of Scale)	64.14	55.62	56.13	60.75
Alertness (% of Scale)	72.30	62.05	64.5	63.5
STM (Letters) (sec)	0.7906*	0.7089*	0.82	0.78
CRT (sec)	0.4723	0.4531	0.61	0.56

* Significant differences
STM= Short-term memory
CRT= Choice reaction time

Donderi *et al.*, (1995) used different measures of sleep quality and alertness (with different scales) than the present study. In order to compare the data, the measures of sleep quality and alertness in both studies were converted to a percentage of their original scale. The assessment of pre- and post-watch alertness for the present study also were averaged for the purpose of comparison, as the previous study used an average alertness calculation.

It appears that the major differences observed between the watch schedules are more dependent on the study and data collection methods used than the watch schedule itself. However, statistical comparison of data from the two studies would be inappropriate because of different experimental design and data collection methods.

3.3 Differences between Day and Night Watches

The third issue of concern to CCG was whether any differences in crew state were apparent between day and night watches. Night watches were defined as any watch that required the individual to be working between the hours of 24:00 and 06:00. All other watches were defined as day watches. Day watches included watches 2 and 3 aboard the Laurier and watches 2 and 4 aboard the Radisson (Table 2.1). Night watches included watch 1 aboard the Laurier and watches 1 and 3 aboard the Radisson. Data tables for individual measures are provided in Appendix D.

3.3.1 Cognitive Assessment

Performance

No significant effects were observed between day and night watches for the Delta tests of cognitive performance (Table D-1). There was, however, a trend for the response time on mathematical processing to be better for the night watch. Inspection of the response time and accuracy data from the other Delta tests also indicated better scores for the night watch. This may have been due to a quieter, less distracting testing environment during the night watch. Every effort was made to provide an environment conducive to testing for both watches, but the day watch was subject to more distractions due to vessel operations. The night watch appeared to have a greater failure rate on the cognitive tests (Table D-2). However, one crew member on the night watch had an abnormally high failure rate (three times greater than average) compared to all other participants.

Situational Awareness

No significant differences were observed between the day and night watches in the pre- and post-watch assessments of situational awareness. However, in both cases situational awareness was slightly higher for the day watch, which suggests that with a larger number of participants it may have been possible to identify a significant change (Table D-3).

Subjective Workload

No significant effects were observed on workload, but the night watch rated several dimensions of workload higher (visual, physical, temporal, effort, and frustration). While both watches rated their effort about the same, there was a trend for the day watch to be more satisfied with their performance and to experience a lower level of frustration than night watch personnel (Table D-4). This may reflect the crew being more tolerant of the day watch over time, which could influence motivation and the quality of crew interaction (Table D-4).

3.3.2 Sleep

Data from the PAM/2 activity monitor and sleep/activity log showed no significant differences between the day and night watches in terms of sleep duration and sleep quality, although the day watch obtained slightly more sleep and slightly better quality sleep (Table D-5). The NightCap data showed a trend for up to 100 minutes more sleep per day for crew on the day watch compared to workers on the night watch (Table D-6). However, the number of subjects was small (day watch n=6; night watch n=3). The measure of sleep latency suggested that crew on the night watch were falling asleep faster, although no significant effects or trends were observed. Overall, the data suggest that crew on the day watch obtained more sleep, and that crew on the night watch were more sleepy and fell asleep faster.

3.3.3 Fatigue

Subjective Assessment of Task and Mental Performance

No significant differences or trends were observed between the day or night watch in terms of percentage of crew indicating degraded mental or degraded task performance. However, of the crew who indicated degraded mental performance, the night watch experienced consistently greater difficulty with decisions, memory, simple tasks, concentration, and apathy. Overall, the magnitude of these symptoms was small (Table D-7).

3.3.4 Socio-Psychological Factors

Mood

No significant differences between the day and night watch were observed in the pre-watch assessment of mood, but there was a trend towards more cheerfulness and an overall pattern of better mood with day watch personnel (Table D-8). Day crew were also significantly more cheerful, calm and confident at the time of the post- watch mood assessment (Table D-9).

Group Dynamics, Morale, and Response to Stress

No significant differences were found between the day and night watches for group dynamics, morale, and response to stress. In terms of group dynamics and morale, there was a trend for leadership skills to be rated higher on the day watch. Overall, the day watch was slightly better in terms of group dynamics, morale, and response to stress (Table D-10).

3.3.5 Additional Measures

Frequency of Daily Medication

No significant differences were observed between the day and night watches for frequency of taking daily medication, although a greater percentage of crew on the day watch were taking daily medication (Table D-11).

Symptoms

No significant differences were observed in the report of pre- or post-watch symptoms for the day and night watches. As well, no trends were apparent, although several symptoms (physical fatigue, apathy and tension/anxiety) were rated higher in the night watch. The higher symptoms were noted in both the pre- and post-watch assessments, but the severity of the symptoms was mild (Table D-12 and D-13).

3.3.6 Summary of the Differences between Day and Night Watches

Based on the cognitive, sleep, fatigue, socio-psychological, and additional measures including symptoms, crew state appears somewhat better on the day watch compared to the night watch. A difference in cognitive performance favouring the night watch is likely the result of a less distracting testing environment since the pattern with the other measures of crew state shows slightly higher levels for the day watch.

3.4 The Impact of 8 versus 15 Days of Icebreaking

Both the Radisson and the Laurier were involved in icebreaking activities during the sailings which were monitored in the summer of 1996. Over the two sailings, a total of 8 days and 15 days of icebreaking were reported by each vessel (Table 3.5), and all icebreaking was completed in the first four weeks of sailing. Thus it was possible to evaluate the effect of 8 days compared to 15 days of icebreaking on measures of crew state. Data tables for all measure of crew state are provided in Appendix E. Only data obtained on days when icebreaking took place were included in this comparison.

Table 3.5:
Icebreaking periods for the Laurier and Radisson.

	Laurier		Radisson	
	First Sailing	Second Sailing	First Sailing	Second Sailing
Day in Cycle	Day 18 to 20 Day 22 to 26	Day 3 to 5 Day 7 to 18	Day 10 to 13 Day 16 to 20 Day 22 Day 24 to 26 Day 28	Day 3 to 8 Day 10 to 11
Icebreaking Periods	8 days total	15 days total	15 days total	8 days total
Relative Time Classification	Late	Early	Late	Early

3.4.1 Cognitive Assessment

Performance

On the cognitive performance tests, no significant differences or consistent pattern of effects were observed between sailings which included 8 compared to 15 days of icebreaking (Table E-1). Failure rates on the cognitive tests appeared to be higher when crew were exposed to 8 days of icebreaking in one sailing, but this effect reversed when data was excluded from the analysis from one subject who had an abnormally high failure rate (Table E-2).

Situational Awareness

No differences were observed in the crew's report of situational awareness between sailings which included 8 compared to 15 days of icebreaking (Table E-3).

Subjective Workload

No significant effects were observed on the NASA TLX between sailings which included 8 compared to 15 days of icebreaking. However, there was a trend for effort and relative workload to be higher during the sailings which included 8 days of icebreaking. During the sailings with 8 days of icebreaking, crew were more satisfied in general with their performance and their frustration levels were lower, even though they reported that they were working harder (Table E-4).

3.4.2 Sleep

Sleep data from the PAM/2 activity monitor and sleep/activity log showed no significant differences between sailings which included 8 compared to 15 days of icebreaking (Table E-5). On the other hand, data from the NightCap showed longer and more efficient sleep during the sailings with 15 days of icebreaking (Table E-6). Data from the NightCap also showed that the crew fell asleep faster during the sailings with 15 days of icebreaking. These effects were not significant but suggest that crew were more in need of sleep when exposure to icebreaking was greater.

3.4.3 Fatigue

Subjective Assessment of Task and Mental Performance

A significantly greater percentage of crew reported degraded mental performance during sailings which included 15 days of icebreaking, but no differences were observed for degraded task performance (Table E-7). However, there were no differences in the value of specific scores (making decisions, memory, simple tasks, concentration and apathy) between the sailings which had 8 compared to 15 days of icebreaking (Table E-8). Furthermore, the magnitude of these symptoms was small.

CO and CE Assessment of Crew Fatigue and Workload

The CO's assessments of crew workload were not different for the crews who were exposed to 8 compared to 15 days of icebreaking. However, fatigue levels were rated as slightly higher during the sailings with 15 days of icebreaking. The CE's assessments also indicated that workload and fatigue were higher for engineering crew during the sailings which included 15 days of icebreaking (Table E-8).

3.4.4 Socio-Psychological Factors

Mood

No significant differences in mood were observed between the sailings which included 8 compared to 15 days of icebreaking. There was a trend, however, for crew to experience more withdrawal during the sailings with 15 days of icebreaking. This was apparent in both the pre- and post-watch mood assessments. Irritability was also higher for the post-watch assessment during the sailings which included 15 days of icebreaking (Table E-9 and E-10).

Group Dynamics, Morale and Response to Stress

For group dynamics, morale and response to stress, no significant differences were found between sailings which included 8 compared to 15 days of icebreaking. However, there was a trend for work scheduling stress to be rated higher during the sailings with 8 days of icebreaking (Table E-11).

3.4.5 Additional Measures

Frequency of Daily Medication

No differences were observed in frequency of taking daily medication between the sailings which included 8 compared to 15 days of icebreaking (Table E-12).

Symptoms

No significant differences or consistent pattern of effects were observed in the report of pre- or post-watch symptoms between the sailings which included 8 compared to 15 days of icebreaking (Table E-13 and E-14).

3.4.6 Summary of the Impact of 8 versus 15 Days of Icebreaking

Overall, crew state appears slightly better during sailings which had 8 compared to 15 days of icebreaking. Some dimensions of workload and work scheduling stress were higher during the sailings with only 8 days of icebreaking, but significantly more crew experienced greater degraded mental performance during the sailings with 15 days of icebreaking, although the associated symptoms were mild. Furthermore, the CO's assessments indicated that crew fatigue was higher, and the CE's assessed both fatigue and workload as higher amongst engineering staff during the sailings which included 15 days of icebreaking.

3.5 The Impact of Icebreaking Early Compared to Late in the Crewing Cycle

The timing of icebreaking activity, which occurred both early and late in the crewing cycle, provided an opportunity to compare its effects on crew state. Early icebreaking occurred over 15 days in total on the Laurier and 8 days in total on the Radisson. Late icebreaking activity took place over 8 days on board the Laurier and 15 days on board the Radisson. No icebreaking occurred after week 4 for the Radisson. Data tables are provided in Appendix F. Only data obtained on days when icebreaking took place were included in this comparison.

3.5.1 Cognitive Assessment

Performance

In the Delta test battery, accuracy on the measure of spatial processing was significantly worse during early compared to late icebreaking. Response time on the successive pattern comparison measure was significantly longer for participants exposed to late icebreaking (Table F-1). Higher failure rates were also observed on the cognitive tests during late icebreaking (Table F-2).

Situational Awareness

In the pre-watch assessment, situational awareness was significantly better for participants exposed to icebreaking early compared to late in the crewing cycle. The same pattern was observed in the post-watch assessment of situational awareness, but the latter difference was not significant (Table F-3).

Subjective Workload

Significantly higher frustration was reported by participants exposed to late icebreaking. There was also some indication that temporal demand was higher and satisfaction with performance was lower for late icebreaking, suggesting that tasks were difficult to complete in the allotted time. No other consistent patterns were apparent (Table F-4).

3.5.2 Sleep

In terms of sleep duration and sleep quality, data from the PAM/2 activity monitor and sleep/activity log showed no significant differences between early and late icebreaking (Table F-5). Close examination of the data revealed that crew slept slightly longer during sailings which included early icebreaking. This was consistent with the NightCap data, where approximately 70 minutes more sleep was recorded for participants exposed to icebreaking early in the crewing cycle. The NightCap results also showed that the crew slept more efficiently and fell asleep faster during late icebreaking. These data suggest that crew were more tired when exposed to icebreaking late in the crewing cycle (Table F-6).

3.5.3 Fatigue

Subjective Assessment of Task and Mental Performance

Subjective assessments of mental and task performance showed no significant differences or trends between participants exposed to icebreaking early and late in the crewing cycle. On the other hand, for late icebreaking, a greater number of the crew reported degraded task and mental performance, showing increased difficulty with decisions, memory, simple tasks, concentration and apathy. However, these effects were not significant and the magnitude of the reported symptoms were small (Table F-7).

CO and CE Assessment of Crew Fatigue

The CO's rating of crew fatigue was higher during the sailing with late icebreaking but no difference was reported for workload during the same sailing. The CEs rated their crews as experiencing higher levels of workload and greater fatigue during sailings in which icebreaking took place early in the crewing period (Table F-8).

3.5.4 Socio-Psychological Factors

Mood

In the pre-watch assessment of mood, significant effects for worse mood were observed during late icebreaking on measures of calmness, withdrawal and irritability (Table F-9). Trends were also observed in the pre-watch mood assessment indicating that icebreaking late in the crewing cycle resulted in lower levels of alertness, cheerfulness, and confidence (Table F-10). In the post-watch assessment, significantly worse mood was found during sailings which included late icebreaking on measures of cheerfulness, withdrawal, irritability, calmness, and confidence. A trend was also observed in the post-watch mood assessment for reduced alertness when icebreaking occurred late in the crewing cycle. These results indicate clearly that icebreaking late in the crewing period has a considerably negative impact on crew state.

Group Dynamics, Morale, and Response to Stress

No significant differences in group dynamics and morale were observed between participants who were exposed to icebreaking early and late in the crewing cycle. There was a trend, however, for leadership skills to be rated worse during late icebreaking. In terms of response to stress, significant effects were found on logistical support, personal control and well-being, and work relationships, all indicating more difficulty with coping with icebreaking late in the crewing cycle (Table F-11).

3.5.5 Additional Measures

Frequency of Daily Medication

No significant differences were observed in the frequency of taking daily medication between participants exposed to icebreaking early compared to late in the crewing cycle. More crew members took medication during early icebreaking, but the difference was not significant (Table F-12).

Symptoms

In the pre-watch assessment of symptoms, physical fatigue was significantly greater for participants exposed to late icebreaking. There was also a trend for these crew members to report more drowsiness, apathy, mental fatigue, and tension. During post-watch assessment, significantly more physical fatigue and tension/anxiety were also reported with late icebreaking. Mental fatigue, drowsiness and apathy showed a similar, negative trend. These results clearly indicate a negative impact on symptoms when icebreaking occurs late in the crewing cycle (Table F-13 and F-14).

3.5.6 Summary of the Impact of Icebreaking Early in the Crewing Period as Opposed to Late

When icebreaking occurs late in the crewing cycle it is clearly more detrimental to crew state than if icebreaking occurs early in the crewing cycle. Although this was not evident in measures of cognitive performance, sleep, and the CE's assessments of fatigue and workload, icebreaking late in the crewing cycle resulted in large negative effects for other measures of crew state. This was particularly evident for several dimensions of mood, ability to cope with stress, and a number of symptoms which were assessed pre- and post-watch. Additionally, the sleep measures suggest that crew may have been more sleepy during late icebreaking.

3.6 Body Temperature Shifts for Night Workers (Adaptation or Re-entrainment)

Body temperature data used to assess changes in circadian rhythm were limited because of irregular crew participation. Participating crew were asked to record body temperature daily at 00:00, 0:400, 08:00, 12:00, 16:00, and 20:00. Sufficient data were only available from two Radisson crew members on the 4&8 watch. Therefore, changes in circadian rhythms were examined as case studies involving partial data as shown in Figures 3.8 (Subject No. 109) and Figure 3.9 (Subject No. 110) and Appendix G. Both participants were from Watch 3 on the Radisson (Table 2.1), where the watch was from 00:00 to 04:00 and 12:00 to 20:00.

For approximately the first three weeks, lows in body temperature occurred most frequently early in the morning. On most days, body temperature highs were recorded later in the day. This pattern is consistent with a normal day watch, which is what these individuals were likely maintaining prior to sailing.

After approximately three weeks on the 4&8 night watches, the lows in body temperature started to occur later in the day with greater frequency. However, the pattern which developed for both crew members was more indicative of a disentrainment in the circadian rhythm than of the re-entrainment to the night watch which might be expected after approximately three weeks. It is likely that the staggered sleeping and working hours associated with the 4&8 watches made re-entrainment difficult. Re-entrainment should be more easily attained on a 12&12 night watch, where patterns of work and rest are more consistent. Disentrainment however, may begin to compromise crew performance after some period of time. Disentrainment of body temperature is associated with reduced sleep duration and quality, which may affect performance, particularly in unusual or unexpected situations.

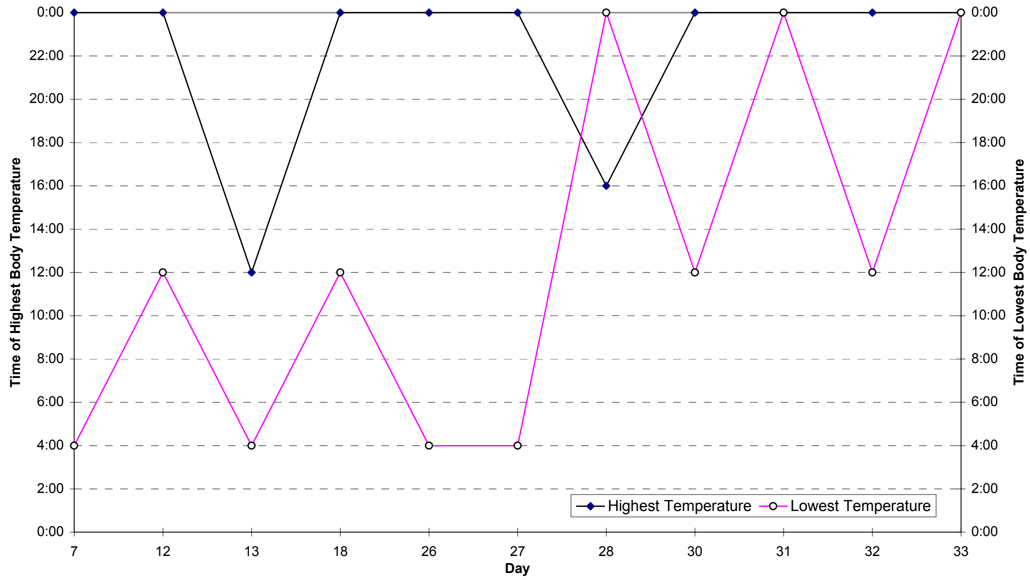


Figure 3.8:
Highest and lowest recorded body temperatures for participant number 109, watch 3 aboard the Radisson.

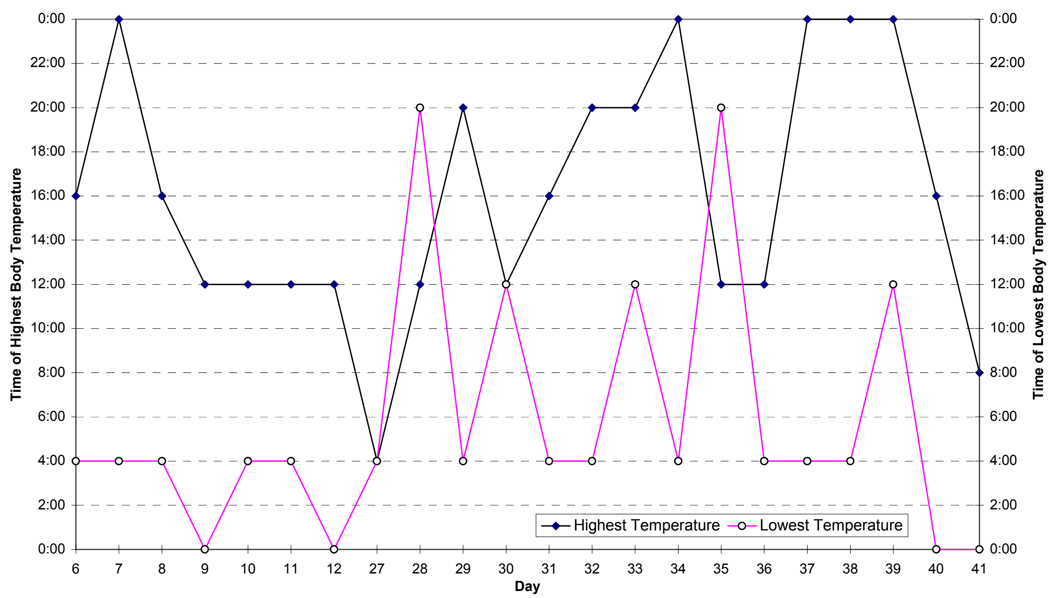


Figure 3.9:
Highest and lowest recorded body temperatures for participant number 110, watch 3 aboard the Radisson.

3.7 Fleet Activity Information System (FAIS)

The FAIS analysis from the Laurier and Radisson and from the Arctic Ivik for 1995 and 1996 are presented in Appendix H. The Ivik is the vessel which sailed in the Western Arctic in 1995 and was used in this study to compare to the Laurier.

In comparing the activity of the Laurier for 1996 to the Ivik for 1995, a greater portion of time was spent breaking ice in 1996, while in both years virtually no time was spent on SAR. During both years, a similar amount of time was spent maintaining vessels in a state of readiness. Overall, these data indicate that in 1996 the level of vessel workload on board the Laurier was greater than for the Ivik in 1995.

On the Radisson, approximately twice the amount of time was spent breaking ice during 1995 compared to 1996 (44 percent versus 26 percent). In 1996, however, a considerably greater proportion of time was spent in SAR (1.6 percent in 1995 versus 19.4 percent in 1996). For both years, similar proportions of time were spent maintaining vessel readiness. If icebreaking alone is used as an index of workload, then 1996 would be viewed as the easier year on the Radisson. If icebreaking and SAR are viewed together as the index of workload, then the 1995 and 1996 workloads are about equal for the Radisson. The latter is likely a more appropriate comparison.

Analysis of the FAIS data illustrates the importance of examining data in the appropriate context before reaching conclusions or making recommendations for change. For example, if the current study had been conducted in 1995, or if the 28-day data used for the 28/42-day comparison had been restricted to the Laurier in 1996, reported differences in crew state may have underestimated the effects of extended crewing periods. The fact that the 28/42-day analysis in this study utilized combined 28-day periods from the Laurier and Radisson means that the results are less biased towards underestimation. Overall, the results from this study may still underestimate the effects of extended crewing periods on crew state.

Based on the FAIS data, no icebreaking was carried out on the Radisson in 1996 during the 5th and 6th weeks of the crewing period. This is also the period when most of the crew state changes were observed. SAR activities were also minimal during the last two weeks, and during one of the Radisson sailings the vessel was relatively inactive during the final weeks. This suggests that changes in crew state which were observed during weeks 5 and 6 on the Radisson were more likely related to the duration of the crewing periods rather than to level of vessel workload. Therefore, in the current study, not only are the results likely a conservative estimate of the level of impact that extended crewing periods have on crew state, but the compromises which were observed are probably related to duration of the crewing period.

3.8 Task Analysis

The task analysis for bridge and engineering watchkeepers is presented in Appendix I. The objective of the task analysis was to identify activities carried out by bridge and engineering crew which are most sensitive to fatigue effects and the possibility of degraded performance.

Aspects of performance affected by fatigue and which are of particular concern to marine safety are: long duration tasks; tasks that are externally paced; complex tasks; tasks with limited feedback; and tasks that require high levels of attention, memory and vigilance. Performance of newly learned tasks and responses to novel situations as well as situations requiring insightful solutions are also particularly sensitive to fatigue. Specific engineering and watchkeeping tasks that fall into these categories are provided in the task analysis. The implications in terms of extended crewing periods in relation to task characteristics are addressed in the recommendations of this report.

4 SUMMARY

The Canadian Coast Guard is interested in extending crewing periods on icebreakers from 28 to 42days. To examine the level of risk to crew and vessel safety, a field study was conducted in 1996 to assess changes in crew state for personnel who were assigned to 28- and 42-day crewing periods on board the icebreakers Sir Wilfrid Laurier and Pierre Radisson. Issues of specific concern in the assessment of crew state were cognitive performance, sleep, fatigue, and socio-psychological well-being for bridge and engineering watchkeepers. Additional issues related to crew state and fatigue included: watch type; duration of ice breaking; the relative time of icebreaking in the crewing period (early or late); workload for bridge and engineering watchkeepers; and changes in circadian rhythms for watchkeepers on night watches.

The results of this investigation are based on patterns of change that were observed across measures of crew state rather than on individual results that attained statistical significance. However, given the level of significance achieved in individual comparisons, these findings must be considered suggestive rather than definitive.

Overall, the results of the investigation can be summarized as follows:

- Initial signs of deterioration in crew state are apparent as the crewing period approaches 42 days. This is suggested by: perceptions by the crew that their performance was starting to degrade; increased frustration, withdrawal irritability, and apathy; and some indication of reduced sleep, particularly after week 4.
- Crew state is moderately better on the 12&12 watch compared to the 4&8, based on the measures of sleep, fatigue, mood, and group dynamics and morale. Although personnel on the 12&12 watch schedule reported higher workloads, they were more satisfied with their performance, more cheerful and recorded better group dynamics and morale. The personnel on the 4&8 ship reported greater frustration, degraded task and mental performance, more withdrawal and greater irritability.
- Compared to the night watch personnel, crew state is somewhat better for workers on the day watch based on cognitive, sleep, fatigue, and socio-psychological measures, as well as additional measures including symptoms. Situational awareness was better for personnel on the day watch. They reported lower levels of frustration and had more sleep (up to 100 minutes per day) than personnel on the night watch. Day watch personnel were also more cheerful, calm and confident, had higher morale, and felt that they responded better to stress.

- The duration of icebreaking activity in a crewing period is an important factor on crew state. When crew were exposed to a total of 8 compared to 15 days of icebreaking in a crewing period, the latter had a more negative impact on crew state. A total of 15 days of icebreaking was associated with crew falling asleep faster, perception of degraded mental performance, as well as greater frustration, irritability and withdrawal.
- When performed late in the crewing period, the negative effect of icebreaking on crew state is greater than that observed when icebreaking takes place early in the crewing period.
- After three weeks, the circadian rhythms of crew on the 4&8 night watch are more variable and do not show signs of adapting to a night watch. However, this information is based on only two case studies. Further study of the circadian rhythms of crew members on various watch schedules is needed to obtain conclusive findings.

For the 28/42-day comparison, crew state appears to be in the initial stages of compromise when the crewing periods exceeding 28 days. The effects on crew state would likely be of little concern during routine operations (when levels of workload are not excessive) because their magnitudes are relatively small and performance under such conditions is somewhat resistant to stress effects. On the other hand, because of the possibility that restricted sleep on the 4&8 watches is accumulating over time, and circadian rhythms may be becoming disentrained with 4&8 night watchkeepers, there is potential for genuine concern. This could be the case, for example, when tasks become less routine, as in the case of search and rescue (SAR), and when workload is high late in the crewing period.

The observation that icebreaking which occurs late in the duty cycle clearly degrades crew state is of particular concern. The higher workload associated with icebreaking could magnify compromises in crew state which may already exist. The fact that no icebreaking took place in the present study after week 4, and that weeks 5 and 6 are associated with the largest changes in crew state suggest that the negative effects of icebreaking late in a 42-day crewing period could be even more extensive than observed in this study.

The improved crew state associated with personnel on a 12&12 watch schedule compared to those on a scheduled 4&8 watch, and with personnel exposed to 8 compared to 15 days of icebreaking may appear minimal when viewed in isolation. When combined, however, these sources of improvement may be useful for offsetting degraded crew state. This should be taken into consideration when designing extended crewing periods.

5 RECOMMENDATIONS

Data from the 28/42-day comparison suggest that the initial stages of compromised crew state appear in a limited way, particularly during weeks 5 and 6. Although the effects observed could be interpreted as relatively mild, there is reason to suspect that they may signal the beginning of performance impairment. Impairment could be manifested under more strenuous or demanding conditions than those observed in the 1996 crewing periods.

The findings in this study do not necessarily mean that extended crewing should be avoided but they do suggest that care should be exercised in implementing longer patrols. It is also possible, however, that the potential deterioration in abilities may be the result of crew being unfamiliar and not sufficiently adapted to lengthy crewing periods. In order for CCG to introduce extended crewing periods the following guidelines are recommended:

- Extended crewing periods should be implemented in an organized manner including continued evaluation of the effects of extended crewing. The current information is not adequate to determine whether there may be adaptation to extended crewing with further experience or whether the deterioration in crew state seen in this study is a precursor to significant performance impairment.

- 12&12 watches may afford better opportunities for improved watch management through modifications to procedures during relatively low workload periods. Crew should be provided with opportunities for strategic rest periods to take naps.

- Anticipated workload should be matched to crew requirements so that the crew can achieve maximal sleep and rest. Such optimal assignment will promote improved morale and a more active crew when they are working.

- Crew preference must be considered before implementing the 12&12 schedule, particularly if it is in a region unfamiliar with this type of watch.

- If 12&12 watches are implemented over an extended crewing period, vigilance testing is recommended. This should be done in conjunction with monitoring select variables, including circadian rhythms, to examine the extent of physiological adaptation with 12&12 night watches, as compared to the 4&8 night watches. Disentrained circadian rhythms, observed in the two case studies of the 4&8 watch, are a source of stress and fatigue, and ultimately performance deterioration.

- Tasks identified by the task analysis as sensitive to fatigue (see Appendix I) should be minimized wherever possible during weeks 5 and 6. When these types of activities cannot be reduced, care should be taken that ample time is allocated for their completion and that they are monitored or checked frequently.

- Tasks identified as sensitive to fatigue by the task analysis should be minimized at night until further circadian rhythm data is collected on the 12&12 night watch.

- Opportunity for crew to rest should be provided during periods of extended icebreaking.

- If icebreaking is late in the duty cycle, additional rest, and extra precaution are required. At this time, sensitive tasks are most vulnerable to disruption and should be minimized wherever possible and carefully monitored if they are essential to vessel operations.

- A training program should be implemented to provide crew with information about coping strategies that will help them deal effectively with extended crewing periods. Consideration should be given to having a crew member trained as a fatigue specialist.

- If crew are given a day off during the crewing cycle, they should be encouraged to maintain the same sleep/wake pattern as if they were working.

- Older crew members should be assigned to day watches, as aging affects an individual's ability to adapt to changes in their sleep pattern.

- The Commanding Officer should provide relief to watchkeepers to help recovery when periods of workload are high or when conditions affect the watchkeepers' ability to obtain adequate rest and sleep.

- Sufficient time off needs to be provided between successive 42-day cycles, to ensure that crew can adequately recover.

6 LIMITATIONS OF THIS STUDY

There are two important types of limitations which need be considered when interpreting the results from this study. The first concerns operational and crewing characteristics of the sailings. The second concerns the level of crew participation. Both may affect the extent to which results can be generalized to other operational settings. These challenges are expected when collecting data in a field study, but affect the experimental design because of variations in sample size across conditions, limited time in which to administer tests, and the influence of other factors such as environmental conditions or interruptions encountered when some tests were in progress. Specific sources of these limitations are discussed in Sections 6.1 and 6.2.

6.1 Limitations Related to Operational Issues and Crewing Characteristics

- Because measures were taken during vessel operations, some of the measures such as the cognitive performance tests were limited to brief time periods before and after watch, and frequently were not completed at all due to time or operational constraints.

- Because of the restricted time frames for measurement during shipboard operations, it was not possible to obtain any objective measures of vigilance by means of sustained cognitive tests. The cognitive test scores in this study therefore likely underestimate performance deficits associated with extended crewing and associated fatigue.

- There were different watch schedules on the two vessels (4&8 and 12&12).

- There were different crewing cycle types on the two vessels, with the entire crew of the Sir Wilfrid Laurier being on a layday cycle and part of crew of the Pierre Radisson being on a conventional cycle.

- There was the possibility of different levels of vessel workload and patrol characteristics for the two vessels.

- There were different locations of sleeping quarters on the two vessels relative to noise exposure.

- There were different types of personnel on the two vessels (some watchkeepers on the Laurier were quartermasters whereas all watchkeepers on the Radisson were officers).
- Different numbers of people were scheduled for duty on the bridge and in the engine room on each patrol and on each vessel.
- General limitations in testing that were posed by the operational environment. For example, testing stopped when vessels were in periods of high workload.
- On the Radisson, watchkeepers worked one additional hour each day to make up for meal times.
- Different numbers of watchkeepers participated from the bridge and engineering.
- There were different relief schedules on the two vessels for breaks and meals.

6.2 Limitations Related to Crew Participation

- Participation in the study was voluntary and several crew members chose not to participate in the study.
- Because of a limited number of subjects and missing data, it was difficult to perform statistical analysis on some of the data.
- Some participants had difficulty operating equipment during periods when investigators were not on board (e.g., problems with computer procedures for the cognitive performance tests).
- Some participants removed monitoring equipment if it had the potential to interfere with activities including sleep (e.g., the PAM/2 activity monitor was frequently removed prior to sleep).
- There were limited numbers of participants with specific sets of attributes (e.g., night bridge watchkeepers on either a 4&8 or 12&12 watch). Limited numbers of participants reduces the power of statistical comparisons and introduces the possibility of individual differences having a stronger effect.
- Pooling of participants wherever possible has the advantage of increasing sample size but also introduces increased variability from crew related variables that are not specific to watchkeeping positions.
- The pooling of data also made it difficult to partial out certain issues. This was apparent, for example, when attempting to determine sleep duration for the 4&8 watch on the Radisson.

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APPENDIX A

Workplan: Study on Extended Crewing Periods

TABLE OF CONTENTS

1 INTRODUCTION...1

2 EXPERIMENTAL METHODOLOGY...2

2.1 Objectives 3
2.2 Subjects 3
2.3 Equipment...4
2.4 Arctic Icebreaking Trials 4
2.4.1 Data Collection Schedule...5
2.4.2 Methodology 6
2.4.3 BCRI Procedures On-board...10

3 EXPERIMENTAL DATA COLLECTION METHODS 12

3.1 Informed Consent 12
3.2 Medication Information 12
3.3 General History Questionnaire 12
3.4 Personality Inventory 13
3.5 Task Analysis...13
3.6 Ship Activity Log...13
3.7 Cognitive Performance Test Battery (DELTA)...13
3.7.1 Associative Memory...14
3.7.2 Information Integration/Manipulation (linguistic/symbolic mode)...14
3.7.3 Information Integration/Manipulation (spatial mode) 14
3.7.4 Output/Response Execution (motor speed)...15
3.8 Subjective Workload Assessment...15
3.9 Subjective Performance Assessment Questionnaire 15
3.10 Situational Awareness Questionnaire...15
3.11 Sleep/Activity Log...16
3.12 Activity Monitoring 16
3.13 Nightcap 16
3.14 Commanding Officer's Assessment of Crew Fatigue 17

3.15 Body Temperature Measurements 17
3.16 Mood Assessment Questionnaire 17
3.17 Socio-psychological Questionnaire: Group Dynamics and Team Cohesion 17
3.18 Subject Debriefing 18
3.19 Environmental Factors 18

4 REFERENCES 19

APPENDIX A1
GENERAL HISTORY QUESTIONNAIRE

APPENDIX A2
INFORMED CONSENT FORM

APPENDIX A3
MEDICATION INFORMATION QUESTIONNAIRE

APPENDIX A4
PERSONALITY INVENTORY

APPENDIX A5
SUBJECTIVE WORKLOAD ASSESSMENT

APPENDIX A6
SUBJECTIVE PERFORMANCE ASSESSMENT QUESTIONNAIRE

APPENDIX A7
SITUATIONAL AWARENESS QUESTIONNAIRE

APPENDIX A8
SLEEP/ACTIVITY LOG

APPENDIX A9
COMMANDING OFFICER'S ASSESSMENT OF CREW FATIGUE

APPENDIX A10
MOOD ASSESSMENT QUESTIONNAIRE

APPENDIX A11
SOCIO-PSYCHOLOGICAL QUESTIONNAIRE: GROUP DYNAMICS AND TEAM COHESION QUESTIONNAIRE

APPENDIX A12
ENVIRONMENTAL FACTORS QUESTIONNAIRE

LIST OF TABLES AND FIGURES

Table 1: Suggested Performance and Physiological Measures 7

Table 2: Data Collection Grouped by Subject Type 8

Table 3: Outline of data collection periods including: measures, crew, and time required 9

Figure 1: Data collection schedule where:..6

1 INTRODUCTION

The following document outlines the recommended experimental methodology for a study being carried out for the Transportation Development Centre (TDC) by B.C. Research Inc. (BCRI) entitled "Study on Extended Crewing Periods" (SSC File No. XSD95-00074-(671)A). Section 2 describes the methodology for this project involving sea trials with two Canadian Coast Guard (CCG) Icebreakers. Section 3 provides a description of the data collection methodologies being proposed for the project. The present document also includes a set of appendices containing supporting documentation referred to throughout the text (e.g., specific tests and forms). This is a working document and as such it will be added to and revised in an ongoing manner throughout the experimental development portion of this project.

2 EXPERIMENTAL METHODOLOGY

Fatigue effects associated with shiftwork, watchkeeping and sustained operations are of increasing concern in terms of performance levels and safety. With an aging work force, staff reductions, and increases in monitoring tasks related to automated technologies, fatigue effects have become a significant problem in modern society. The recent catastrophic systems failures of Chernobyl, the space shuttle Challenger, and the Exxon Valdez have in large part been attributed to fatigue, and underscore the critical importance of developing a more thorough understanding of human capabilities and limitations in relation to fatigue, shiftwork and watchkeeping in modern work environments.

Sustained operations and watchkeeping schedules in the marine environment are of particular concern. The earliest literature on marine watchkeeping, from the thirteenth century, documents the traditional 4h on/4h off schedule. Much of the basis for having a 4h work period was due to the extent of physical labour and exposure to harsh environmental conditions. With advances in technology and changes to the nature of task characteristics, longer shifts became possible. In more recent years there has been considerable interest in examining alternate watchkeeping schedules in relation to crew performance and fatigue levels.

Recently, Transport Canada compared the impact of two shift schedules (6&6 vs. 4&8) on Canadian Coast Guard (CCG) watchkeepers for a 28 day crewing period in SAR and Buoy Tenders. In this study entitled "Shift Schedule Comparison for the Canadian Coast Guard" (Donderi et al., 1995), measures of performance were choice reaction time and short term memory. Measures of well-being included ratings of mood, alertness and sleep quality, as well as personal sleep diaries. Although crew on the 4&8 watch obtained longer periods of uninterrupted sleep, measures of total sleep time, performance and mood did not differ significantly for the two schedules. However, on the basis of their findings, it was recommended that a modified 4&8 shift be used for the day watch and a 6&6 for the night watch.

The CCG is considering the extension of crewing periods in Arctic icebreaking operations from 28 days to 42 days. Extended crewing periods are aimed at providing better service to Coast Guard clients by reducing excursions to shore for crew changes, which are expensive and which impact on client schedules. As the data from the shift schedule comparison study completed in 1995 are unable to address how watchkeepers would perform under these extended 42 day crewing conditions, additional studies are required.

2.1 Objectives

The objective of this project is to assess the impact of 42 day versus 28 day crewing periods on watchkeepers' level of fatigue, alertness, sleep, cognitive performance and socio-psychological well-being in Arctic icebreaking operations. The proposed research methodology will combine procedures identical to those employed by the previous shift schedule comparison study (Donderi et al., 1995), with a protocol of additional tests designed to increase the scope and sensitivity of the data collection. Additional measures being recommended provide a more in-depth assessment of sleep characteristics, skilled task performance and behavioural issues associated with mood and socio-psychological well-being. The methodology recommended in this proposal is based on a review of the literature, with a specific focus on the issues presented in the statement of work and previous related studies.

2.2 Subjects

Subjects will be current CCG crew assigned to Arctic icebreakers. The vessels for this project will be identified by CCG. Subjects may be male or female, depending upon crew composition. All subjects will be fully informed volunteers and will have had varying degrees of experience with CCG, which will be identified by means of a general history questionnaire (Appendix A1). Crew may choose not to participate, or to discontinue participation at any time during the testing, without reprimand. All data will be held confidential and results will only be given in summary form so that individual subject responses cannot be traced.

Data collection will focus on the bridge and engine room watchkeepers. However, it is recognized that this will provide a limited number of subjects (approximately 6 per vessel) and therefore limits the statistical power of the study. Therefore, it is recommended that other bridge and engine room crew who work on shift schedules are encouraged to participate to a maximum of 10 watchkeeping subjects per vessel to allow for a more robust study. Other crew members will be encouraged to participate in some of the measures as outlined in Table 3.

Each subject will provide computerized cognitive performance data and subjective ratings, as well as sleep/activity records and body temperature measurements. Physiological data may be gathered at specific times from watchkeepers, provided it is acceptable to the crew and is not deemed intrusive to their routine operations. Details concerning the types of measures to be used and their relevance to the project are included in Section 3. Because a higher rate of subject compliance can be expected with a brief and concise data collection period, the primary data collection periods will be limited to 10 minutes.

Prior to data collection, all participants will be briefed on the intent of the study, and will be asked to complete an informed consent form (Appendix A2). Participating crew will be familiar with and will practice with all aspects of the experimental protocol. Immediately following the 42 day data collection period, participating crew will be debriefed.

2.3 Equipment

- Informed consent: to ensure subject confidentiality (Section 3.1)
- Medication information (Appendix A3): to establish use of medication potentially related to fatigue (Section 3.2)
- General History Questionnaire: to determine previous history with CCG and shiftwork cycles (Section 3.3)
- Personality Inventory (Appendix A4): to assess personality types related to shiftwork issues (Section 3.4)
- Video camera: used to assist a task analysis of bridge and engine room watchkeepers (Section 3.5)
- Laptop PC: used to collect computerized cognitive tests (Section 3.5) and to down-load physiological data
- PAM2 or Actigraph: an ambulatory monitoring device to determine sleep/activity cycles (Section 3.12)
- Nightcap: an oculometry monitoring device to assess sleep quality (Section 3.13)
- Temperature recording device (tympanic): a method of determining circadian rhythms (Section 3.15)
- Subject data diary:
  Subjective Workload Assessment (Section 3.8; Appendix A5);
  Pre/Post/Mid-shift Assessment of Fatigue and Performance (Section 3.9; Appendix A6);
  Situational Awareness Questionnaire (Section 3.10; Appendix A7);
  Sleep/Activity Log (Section 3.11; Appendix A8);
  Commanding Officer's (CO) Assessment of Crew Fatigue (CO diary only) (Section 3.15; Appendix A9);
  Mood Assessment Questionnaire (Section 3.16; Appendix A10);
  Group Dynamics and Cohesion Questionnaire (Section 3.17; Appendix A11)
- Environmental measurement devices, including: noise meter; and subjective environment assessment questionnaires (Section 3.19; Appendix A12)

More detailed information on the equipment listed is provided in appropriate components of Section 3.

2.4 Arctic Icebreaking Trials

As indicated in Section 2, this study will examine the effects of shift cycles and extended crewing periods on icebreaking vessel crew, in terms of subjective effects, cognitive performance and physiological measurements including circadian rhythms and sleep quantity and quality. During the data collection period, it is planned that two sailings of 42 days will be included in the study. The vessels are away from port for the majority of the crewing period and crew members spend their off duty hours on-board. Due to ship scheduling, financial constraints and logistical issues, the same ship and crew will be used to study both the 28 day and the 42 day crewing periods. Each ship will perform a 42 day cycle and the first 28 days will be studied as the standard crewing period. However, a serious issue of crew motivation may compromise performance measured during the initial 28 day period as the crew will be aware that they will be at sea for an additional 14 days. This could affect the level of motivation, particularly around the 28 day mark, which is the time that the crew change would normally occur. Data interpretation must consider these factors. In addition to these two sailings, another vessel will be used to study the 28 day crewing period with a 12&12 shift schedule; this will be a control for comparison to the 42 day cycle and to supplement data collected in a previous study. This approach will provide greater reliability and will increase the ease of data collection.

In the initial statement of work, TDC and CCG requested that various types of shift cycles be examined during these crewing periods, including a 12&12, 4&8 and 6&6 schedules. However, in the interest of crew participation and scheduling feasibility, a decision was made in conjunction with TDC and CCG to follow the shift schedule currently in place on the participating vessels.

2.4.1 Data Collection Schedule

A BCRI team member will be present on-board at the beginning and end of the 42 day period to initiate the project and complete administrative procedures with the crew. When appropriate, the investigator will disembark at a local port or by CCG helicopter. BCRI recognizes that travel to remote locations in the Arctic, including lighthouses or small ports may be difficult or unfeasible. CCG support or private charter by helicopter or sea plane from locations without commercial airports may be required. The following outlines the schedule for the presence of the BCRI investigator on-board the vessel:

For the first 42 day cycle, BCRI will be on-board for the first 7 to 10 days. An investigator will then rejoin the vessel in the middle of the cycle, on approximately day 26, and remain on board for the duration of this sailing. This schedule bridges the transition of the 28 day to 42 day study. The investigator will remain on board for the first 7 to 10 days of the next sailing and will rejoin the vessel around day 26 of the second 42 day sailing as outlined in Figure 1.

Travel			**1**	**2**	**3**	**4**
5	**6**	**7**	**8 Travel**	**9**	**10**	**11**
12	**13**	**14**	**15**	**16**	**17**	**18**
19	**20**	**21**	**22**	**23**	**24**	**25 Travel**
26	**27**	**28**	**29**	**30**	**31**	**32**
33 Travel	**34**	**35**	**36**	**37**	**38**	**39**
40	**41**	**42**	**1** Crew Change	**2**	**3**	**4**
5	**6**	**7**	**8 Travel**	**9**	**10**	**11**
12	**13**	**14**	**15**	**16**	**17**	**18**
19	**20**	**21**	**22**	**23**	**24**	**25 Travel**
26	**27**	**28**	**29**	**30**	**31**	**32**
33 Travel	**34**	**35**	**36**	**37**	**38**	**39**
40	**41**	**42**			**Travel**	

Figure 1:
Data collection schedule where:

Set-up/tear-down BCRI on-board, and Data collection supervised by senior CCG member

This schedule will allow data collection for the end of the 28 day period using measures which require the presence of an on-board investigator. This will include sleep assessment using an oculometry monitoring device (Nightcap). This additional presence of the on-board BCRI investigator will also bolster subject participation and ensure that computerized cognitive task performance and subjective assessment questionnaires are being completed during this important portion of the study.

This schedule provides monitored data collection during the transition period from the 28 to 42 day cycle. With assistance from CCG, BCRI will make every effort to follow this schedule. However, measures will be taken to ensure flexibility in onboard time commitments and requirements.

2.4.2 Methodology

A comprehensive measurement battery has been proposed to assess the effects of shift cycles and crewing period on watchkeeping activities. These measures include: subjective assessment of performance; socio-psychological factors; fatigue; cognitive task performance; physiological measures of sleep and circadian rhythms; task analysis; and ship activity analysis. These measures and subjects who will provide corresponding data are outlined in Table 1. More detailed information regarding each of the measures is provided in Section 3.

Table 1:
Suggested Performance and Physiological Measures

Experimental Parameters	Measurement Technique	Subjects
Cognitive Task Performance	DELTA Performance Battery-including short term memory and choice reaction time as in PAB	Watchkeepers
	Situational Awareness Questionnaire	Watchkeepers
	Subjective Workload Assessment	Watchkeepers
Sleep and Activity	PAM2/Actigraph	Watchkeepers
Patterns	Sleep assessment (Nightcap)	Watchkeepers
	Sleep/Activity Log	Watchkeepers
Fatigue	Subjective Assessment of Performance	Watchkeepers
	Commanding Officer Assessment of Crew Fatigue	Commanding Officer
Circadian Rhythms	Body temperature (tympanic)	Watchkeepers
Socio-psychological	Mood Assessment Questionnaire	All
Factors	Group Dynamics and Team Cohesion Questionnaire	All
Other measures	General History Questionnaire	All
	Task analysis	Watchkeepers
	Personality Inventory	All
	Medication Information Questionnaire	All
	Subjective assessment of noise, lighting and temperature	All
	Ship activity log	
	Noise level measures in sleeping quarters	

As outlined in Table 2, watchkeepers will provide a core set of data, while all subjects will participate in additional measures. The core measures provide physiological data on sleep-wake patterns and levels of fatigue. The number of subjects involved in these measures are limited due to subject participation requirements, equipment availability and data reduction.

Table 2:
Data Collection Grouped by Subject Type

All Subjects	Watchkeepers Only
General History Questionnaire	Sleep assessment (Nightcap)
Personality Inventory	PAM2/Actigraph
Medication Information Questionnaire	Body temperature
Subjective assessment of noise, lighting and temperature	Data diary
Team Cohesion Questionnaire	DELTA test battery
Informed consent	
Subject debriefing	

Table 3 outlines the frequency and duration of each measure during the data collection schedule, as well as those subjects who will be involved in its collection.

Table 3:
Outline of data collection periods including: measures, crew, and time required

	Subjects	Completion Time
Before, after and during shift		**10 minutes in total**
Subjective Performance Assessment Questionnaire	Watchkeepers	
DELTA Test Battery	Watchkeepers	
Situational Awareness Questionnaire	Watchkeepers	
Subjective Workload Assessment	Watchkeepers	
Commanding Officer Assessment of Crew Fatigue	Commanding Officer	
Mood Assessment Questionnaire	Watchkeepers	
ONCE PER DAY		
Sleep/Activity Log	All	5 minutes
EVERY TWO WEEKS		
Group Dynamics and Team Cohesion Questionnaire	All	5 minutes
Mood Assessment Questionnaire	All	
ONGOING COLLECTION		
PAM2/Actigraph	Watchkeepers	Ongoing
Body temperature (tympanic)	Watchkeepers	Ongoing
ONLY WHEN BCRI IS ON-BOARD		
Oculometry (Nightcap)	Watchkeepers	
Task analysis	Watchkeepers	
Ship activity log		
Noise level measures in sleeping quarters		
ONE-TIME-ONLY MEASURES		
General History Questionnaire	All	15 minutes
Personality Inventory	All	5 minutes
Medication Information Questionnaire	All	5 minutes
Subjective assessment of noise, lighting and temperature	All	5 minutes

Subjective assessment of performance, mood, situational awareness and the DELTA tests will be collected before each shift. A modified, mid-shift assessment, including: DELTA tests, Mood Assessment and an overall Subjective Workload Assessment, will be performed by subjects during the night shift only. This additional data collection is recommended to assess the 'zones of vulnerability' which are time periods that may be particularly sensitive to decrements in task performance during the trough of the circadian rhythm, occurring between 0200h and 0600h (Smith et al., 1995; MacDonald et al., 1995). In the interest of subject compliance, task interference and time constraints, this data collection will occur after the third hour of the shift and will be restricted in size and duration (i.e., 5 minutes). Subjective assessment of performance, mood, workload assessment, situational awareness and the DELTA tests will be collected after each shift. In the event that a shift consists of day work (office duties) and watchkeeping duties, data collection will occur at the beginning and end of the watchkeeping period.

2.4.3 BCRI Procedures On-board

Administrative procedures to be performed by BCRI investigators during the first 10 days of the crewing period include:

- briefing of crew on purpose of study and on their requirements as participants
- familiarization of subjects with experimental protocol
- completion of Informed Consent Form
- completion of Medication Information Questionnaire
- completion of General History Questionnaire
- completion of Personality Inventory
- distribution of ambulatory monitoring devices (e.g., PAM2/Actigraph and Nightcap) to watchkeepers
- distribution of subject project diaries, which in addition to containing material described in Section 2.3, will also include contact numbers of BCRI staff
- training subjects on the cognitive performance test battery to reduce learning effects
- designation of a room or area on the vessel to allow uninterrupted data collection
- training watchkeepers on procedures for taking physiological measures (i.e., PAM2/Actigraphs, body temperature)
- scheduling and collection of body temperature data (tympanic)
- training senior crew member to supervise the experimental protocol during the absence of the experimenter
- scheduling and collection of sleep assessment data on watchkeepers (i.e., Nightcap)

- completion of the task analysis for the bridge and engine room watchkeeper
- collection of ship activity logs for previous one year period
- collection of objective and subjective measures of noise, light and temperature.

During the final 17 days of the crewing cycle, the BCRI investigator will perform these tasks:

- organization and supervision of data collection (e.g., DELTA computerized cognitive test battery, data diary)
- collection of sleep assessment data on watchkeepers (Nightcap)
- collection of data logs, body temperature data, cognitive task performance data, and equipment and prepare them for shipment
- collection of body temperature data (tympanic)
- down-loading and back-up of physiological and computerized data
- completion of subject debriefings
- completion of task analysis (if required)
- collection of event listing of ship activity over 42 day period

3 EXPERIMENTAL DATA COLLECTION METHODS

The following measures have been selected for data collection during the sea trials. More detailed information and examples of specific documents are included in the corresponding appendices.

3.1 Informed Consent

Prior to collecting any data from the crews, all participants will be briefed as to the intent of the study and familiarized with all aspects of the experimental protocol, including completion of an informed consent form (Appendix A2).

3.2 Medication Information

Subjects will be asked to complete a brief questionnaire at the beginning of the experiment to establish their use of any medication throughout the collection period. A copy of the medication information form is provided in Appendix A3.

3.3 General History Questionnaire

During the initial phase of the experimental protocol, subjects will be asked to complete a questionnaire to assess how their on-board duty performance and general well-being is affected by fatigue and shift work scheduling. The questionnaire includes information on general demographics such as CCG experience and type of duty cycle, as well as information on the relationship between shift types and the social, domestic, psychological and physical well-being of subjects. This questionnaire will be based on a questionnaire which was distributed to Canadian air traffic controllers to assess shift work and well being (Heslegrave, 1995) and which has been modified to assess issues relevant to fatigue in CCG SAR operations in another BCRI project which is ongoing (The Effects of Vessel Motion and Fatigue on Target Detection Performance in Search and Rescue (SAR) Operations: SSC File No. XSD94-00185-(621)/A). Questionnaires will be provided to subjects at the beginning of the duty cycle. Subjects will complete the questionnaires during the initial briefing at the beginning of the duty cycle. If a need for a French version of the questionnaire is identified, BCRI will provide translated questionnaires to specified vessels. These questionnaires may be distributed to selected personnel on other icebreaking vessels upon recommendation from CCG. A copy of the General History Questionnaire is provided in Appendix A1.

3.4 Personality Inventory

The standard Eysenck personality inventory will be used to assess levels of introversion and extroversion for each participating crew member. The extent to which crew are morning or evening types will also be assessed using a simple one-time questionnaire developed by Horne and Osterberg (1976). As indicated in the literature review, identification of these two types of individuals (personality and chronobiological type) is important with respect to issues of task performance, shift schedules and the ability to obtain effective sleep at different times. A copy of the Personality Inventory is provided in Appendix A4.

3.5 Task Analysis

A comprehensive task analysis of the watchkeepers' activities will be performed to identify types, duration and time of occurrence of critical activities that may be particularly sensitive to fatigue. The BCRI team has completed a task analysis of navigators and lookouts on Type 500 and Type 300 Coast Guard vessels as a component of a current contract evaluating the effects of vessel motion and fatigue on target detection performance in search and rescue (SAR) operations (SSC File No. XSD94-00185-(621)/A). This approach will be applied to the bridge of the icebreakers and additional task analysis will focus on engine room watches where there is a potential for significant noise and vibration exposure. Task analysis will include direct observation, watchkeeper interviews, and video recording and analysis.

3.6 Ship Activity Log

An evaluation of the activity of the ship during the crewing period being studied will be performed to track significant ship events during data collection periods. Examination of the ship's log and interviews with the CO will provide information on icebreaking activities, critical incidents, contact with other vessels and other events which may relate to levels of fatigue and may affect the results of the experiment. This information will also be compared to the activity level of the ship over the previous year to compare ship activity during the experimental protocol with that of a typical crewing period. In addition, these data on ship activity over the year will be collected to compare workloads between vessels.

3.7 Cognitive Performance Test Battery (DELTA)

The DELTA Performance Test Battery is currently being used by BCRI in a TDC/CCG project to evaluate the effect of motion and fatigue on target detection performance in SAR operations (SSC File No. XSD94-00185-(621)/A). A number of cognitive performance test batteries were assessed for potential use in this study and the DELTA test battery was selected after a thorough investigation of available performance assessment tools. Criteria which were considered in the selection included: an evaluation of face validity; documentation of psychometric properties (including learning, reliability, sensitivity and validity); ability to modify the protocol; ability to transfer data to analysis applications; software support; and reliability and stability of software. The DELTA Performance Test Battery was chosen based on these criteria, as well as on the fact that it has been used extensively in similar settings. Subjects will complete the DELTA test using a laptop computer via keyboard input and will identify their entries by an assigned identification number before each data collection period. The data will be down loaded at the end of the 42 day duty cycle.

The following measures will be included in the DELTA battery being developed for this study. Specific tests have been chosen because of their sensitivity to fatigue and because of their relevance to watchkeeping tasks, based on the initial task analysis in the current TDC/CCG study. The watchkeeping tasks to which the tests are related include: visual tracking; signal detection; and mathematical competency (speed and accuracy). Tasks which are externally paced are also suggested to be more sensitive to fatigue.

3.7.1 Associative Memory

- Short term memory (letters). This test involves the presentation of a set of four letters (positive set), followed by a series of single letters (probe letters). The subject's task is to determine if any of the probe letters are contained in positive set.

3.7.2 Information Integration/Manipulation (linguistic/symbolic mode)

- Logical reasoning. This logical reasoning test presents the subject with a complex sentence expressing the positional relationship for two symbols, A and B. Reasoning, symbol manipulation, logic and verbal ability are the important factors in this test.

- Mathematical processing. This test examines the processing of mathematical operations as well as value comparison of numbers. The subject performs three addition or subtraction operations in a single presentation and indicates whether the total is greater or less than the number five, using the arrow keys.

3.7.3 Information Integration/Manipulation (spatial mode)

- Spatial processing (Manikin). This test requires the subject to mentally manipulate objects and determine the orientation of a given stimulus. It is a perceptual measure of spatial transformation of mental images and involves spatial ability.

- Successive pattern comparison. This test is designed to measure visual pattern recognition and spatial memory. A random pattern of asterisks is displayed briefly on the screen. It is followed after a fixed interval by a second pattern of asterisks that may be the same or different.

3.7.4 Output/Response Execution (motor speed)

- Four-choice reaction time. This test assesses the subject's ability to encode and categorize information. In the test, a plus sign (+) is displayed in one of four quadrants of the screen. The subject responds by pressing an arrow key (one of four directions) on the keyboard which corresponds to the quadrant containing the plus sign.

The measures on choice reaction time and short term memory which were originally in the Walter Reed Performance Assessment Battery (PAB) will be incorporated into the DELTA test battery. Similar measures are tested in the DELTA Four Choice Reaction Time test as the PAB Serial Choice Reaction Time test; and in the DELTA Short Term Memory test as the PAB Sternberg Memory Search Test. Because of the high level of similarity between these tests on the PAB and DELTA, comparisons will be possible with previous studies.

3.8 Subjective Workload Assessment

A Subjective Workload Assessment has been developed by BCRI based on the NASA Task Load Index (NASA TLX) to allow subjects to assess the level of workload required during their shift. The NASA TLX is a multi-dimensional subjective workload measure which has been validated extensively in a range of operational environments. It is a standard tool for assessing residual processing capacity in terms of physical, mental and temporal demand. Frequently, workload measures show greater sensitivity than performance measures to environmental stress. The Subjective Workload Assessment questionnaire is extremely quick to administer as it uses visual analog scales and can be completed within 30 seconds. An example of the questionnaire is in Appendix A5.

3.9 Subjective Performance Assessment Questionnaire

A Subjective Performance Assessment questionnaire has been developed by BCRI based on the Defence Research Establishment Atlantic (DREA) Performance Assessment Questionnaire (PAQ) (Colwell and Heslegrave, 1993). The PAQ has been used in a number of studies evaluating human performance in marine environments. A modified version which is currently being used by the BCRI team in a CCG project has been customized for the Arctic icebreaking project (Appendix A6) to assess fatigue and subjective estimates of performance. Subjects will complete these questionnaires before and after each shift.

3.10 Situational Awareness Questionnaire

Situational awareness is used as a measure of one's potential to perform in complex environments, particularly with reference to marine and flight operations (Endsley, 1995; Federico, 1995). Situational awareness refers to one’s overall appreciation of system status and knowledge of current and future variables relative to mission objectives. In this study, situational awareness will include factors relevant to ship operations. The Situational Awareness Questionnaire will be brief, using a visual analog scale (Appendix A7).

3.11 Sleep/Activity Log

Each subject will be asked to keep a daily record of general waking and sleep activities by completing a sleep/activity log. This log includes the duration of sleep and the number and type of interruptions during the sleep cycle. Activities are categorized as being work or leisure including overtime, physical work, meals, alcohol consumption, caffeine consumption and the use of tobacco. Subjects will be asked to rate the quality of their sleep after each sleep cycle on-board. They will also be asked to rate their sleep and activity for the five days before the start of the protocol to provide a baseline for comparison of sleep and fatigue from on-duty to off-duty. A sample of the sleep/activity log is provided in Appendix A8.

3.12 Activity Monitoring

Ambulatory monitoring devices (i.e., PAM2 or Actigraphs) will be used to establish behavioral activity patterns, and to assist in characterizing sleep duration and quality (Brooks et al., 1988). Subjects will wear a wrist watch-type measurement device during waking periods and during sleep to monitor the level of body activity. These devices are considered to be low-risk to the subject as they are battery powered and therefore isolated from a main power source. The data will be down loaded using software and equipment compatible with the PAM2 or Actigraphs based on the option selected for the data collection schedule as outlined in Section 2.4.1. For Option 1, the data will be down-loaded before the BCRI investigator leaves the vessel after the first 10 days on-board and again when the investigator rejoins the vessel for the final 10 days. For Option 2, the data will be down-loaded after 28 days when the investigator returns to the ship at the midpoint of the crewing period.

3.13 Nightcap

Data will be collected on eye blink activity using a commercial sleep monitoring system called the Nightcap. The Nightcap provides a means of assessing sleep by recording normally unnoticed tremor of the eyelid. The tremor reflects normal fluctuations in the activity of the small muscle which controls activity of the upper eyelid (levator palpebrae superioris). The data collected from the Nightcap provides an assessment of sleep by establishing awake time, REM sleep, non-REM sleep and head movement.

Subjects will wear the device during sleep cycles (excluding naps) while the BCRI investigator is on-board the vessel. The investigator will be available during the initial period of the duty cycle to assist in instruction, instrumentation and administration of the Nightcap. The Nightcap has been designed to require simple instrumentation and present low-risk to the subject for use in applications such as this project.

3.14 Commanding Officer's Assessment of Crew Fatigue

Because of the extent of the operational experience of the bridge and engineering Commanding Officers (CO), their assessment of crew fatigue on the basis of bridge and engineering activity is considered a particularly relevant measure. This will involve a simple subjective rating of crew fatigue on a visual analog scale after changes in watch. The questions will be incorporated into the Commanding Officer's data diary. A copy of the assessment is provided in Appendix A9.

3.15 Body Temperature Measurements

The body temperature of the watchkeeping personnel will be collected at six points over a 24 hour period during selected days of the 42 day crewing period. The days include the first ten of the duty cycle, 6 days in the middle of the duty cycle (days 26-31) and the last ten days of the duty cycle. The times suggested include: at initial waking, before each of the two main daily meals, before bed and two other time during the shift to be determined. The purpose of this measurement is to monitor the circadian rhythm and determine when critical activities and sleep are occurring within the biological cycle. Tympanic body temperature will be measured. This method is non-intrusive, simple and has good reliability. Body temperature will be measured and recorded by each subject.

3.16 Mood Assessment Questionnaire

Mood will be evaluated as in the previous shift work comparison study which included measures of calmness, cheerfulness and alertness (Donderi et al., 1995). Based on recommendations by the U.S. Department of Transport (Colquhoun et al., 1968a, 1968b) and other literature, withdrawal, irritability and level of confidence will also be assessed. The measures will be collected before and after each shift using visual analog scales. The Mood Assessment Questionnaire are provided in Appendix A10.

3.17 Socio-psychological Questionnaire: Group Dynamics and Team Cohesion

The literature indicates that fatigue impacts on mood, which affects motivation and subsequently task performance and crew dynamics (Stretch and Jameison, 1990). Subjects will be asked to complete a questionnaire every two weeks which will assess group dynamics and cohesion. This questionnaire is based on a version currently being used by the Canadian Forces Personnel Evaluation Research Unit. A copy of this questionnaire is provided in Appendix A11.

3.18 Subject Debriefing

Subjects will participate in a debriefing on the experimental protocol at the end of the 42 day duty cycle. The debriefing will be coordinated by the B.C. Research investigators.

3.19 Environmental Factors

Issues external to the shift schedule or crewing cycle may affect crew performance and comfort in both working areas and sleeping quarters. These factors may include environmental issues, such as lighting, noise and temperature. These factors will be measured subjectively by using questionnaires to assess their effect on bridge and engine room watchkeepers' tasks. Noise levels in the sleeping quarters will be measured in dBA with a standard noise meter. General subjective assessment questionnaires will also be provided to subjects at the beginning of the crewing cycle to provide baseline data on these issues (Appendix A12). Related questions are included in the Pre and Post-shift Subjective Assessment Questionnaire to track daily changes in perceptions of these variables.

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APPENDIX A1

General History Questionnaire

Effects of Extending Crewing Periods on Fatigue during Arctic Icebreaking Operations: Individual Factors Affecting Fatigue

This questionnaire is part of a multi-phase study designed to investigate the effects of extended crewing and associated fatigue during icebreaking operations. Your answers will provide important information concerning personal experiences with Fisheries and Oceans/Canadian Coast Guard. Please remember that your answers are completely confidential. We appreciate your time and cooperation in filling out this questionnaire.

General Demographics

In this section, we would like to obtain information about yourself and your Fisheries and Oceans/Canadian Coast Guard experience. Please check the box next to the appropriate description, or fill in the blank.

1. Age: ________ 2. Gender Male: ❑ Female: ❑

3. Region of country in which you currently work:

Maritimes ❑ Newfoundland ❑ Laurentian ❑ Pacific ❑

4. Current vessel name: ______________________________

5. Primary type of work you currently perform : Bridge watchkeeping ❑ Engine room watchkeeping ❑

Other ❑: ____________________________________

6. Years of sea duty in Fisheries and Oceans/Canadian Coast Guard: _______

7. Years of icebreaking duty in Fisheries and Oceans/Canadian Coast Guard: _______

8. Overall years of duty in Fisheries and Oceans/Canadian Coast Guard: _______

9. Years of duty on current vessel: _________

Crewing Cycle

10. Type of crewing system: conventional ❑ layday ❑

11. Length of cycle (days): 28 ❑ 42 ❑ 56 ❑ other ❑ ___________

12. Do you normally perform shift work? yes ❑ no ❑

If yes, is it rotating or fixed for the duration of the duty cycle? fixed ❑ rotating ❑

13. Watch/shift type: 6&6 ❑ 4&8 ❑ 12&12 ❑

14. Have you found it more difficult to cope with sea duty as you have grown older?
Not at all ❑ Slightly ❑ Much more difficult ❑

Fatigue

1. In this section we would like to obtain information on how different duty requirements and environmental conditions at sea affect your fatigue levels and ability to sleep. Again, we wish to stress that in no way are we assessing your performance for reasons beyond this specific study.

   Please indicate your present shift schedule on the following 24 hour clock. Put an "X" in the boxes indicating hours you usually work and a "0" for hours you usually don't work. If you are on a rotating shift, please describe your shift at the bottom of page 4.

0000h 0200h 0400h 0600h 0800h 1000h 1200h 1400h 1600h 1800h 2000h 2200h 2400h

---

On a scale from 1 to 7 (where 1=not at all impaired and 7=severely impaired). n/a = not applicable.

a. In a normal 28-day icebreaking mission, please indicate:

How your performance (alertness, memory, attention) is affected...	Not at all Impaired 1	2	3	4	5	6	Severely Impaired 7	n/a
On the **first** day of the duty cycle in the **first** hour of your watch	❑	❑	❑	❑	❑	❑	❑	❑
On the **first** day of the duty cycle in the **last** hour of your watch	❑	❑	❑	❑	❑	❑	❑	❑
On the **last** day of the duty cycle in the **first** hour of your watch	❑	❑	❑	❑	❑	❑	❑	❑
On the **last** day of the duty cycle in the **last** hour of your watch	❑	❑	❑	❑	❑	❑	❑	❑

b. When you are on a 28-day crewing cycle on the day shift, please indicate:

How your performance (alertness, memory, attention) is affected...	Not at all Impaired 1	2	3	4	5	6	Severely Impaired 7	n/a
On the **first** day of the 28-day duty cycle in **non-icebreaking** operations (i.e., transit, port)	❑	❑	❑	❑	❑	❑	❑	❑
On the **first** day of the 28-day duty cycle in **icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑
On the **last** day of the 28-day duty cycle in **non-icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑
On the **last** day of the 28-day duty cycle in **icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑

c. If the crewing period was extended to a 42-day crewing cycle on the day shift, please estimate:

How your performance (alertness, memory, attention) would be affected...	Not at all Impaired 1	2	3	4	5	6	Severely Impaired 7	n/a
On the **first** day of the 42-day duty cycle in **non-icebreaking** operations (i.e., transit, port)	❑	❑	❑	❑	❑	❑	❑	❑
On the **first** day of the 42-day duty cycle in **icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑
On the **last** day of the 42-day duty cycle in **non-icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑
On the **last** day of the 42-day duty cycle in **icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑

d. When you are on a 28-day crewing cycle on the night shift, please indicate:

How your performance (alertness, memory, attention) is affected...	1 Not at all Impaired	2	3	4	5	6	7 Severely Impaired	n/a
On the **first** day of the 28-day duty cycle in **non-icebreaking** operations (i.e., transit, port)	❑	❑	❑	❑	❑	❑	❑	❑
On the **first** day of the 28-day duty cycle in a **icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑
On the **last** day of the 28-day duty cycle in **non-icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑
On the **last** day of the28-day duty cycle in a **icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑

e. If the crewing period was extended to a 42-day crewing cycle on the night shift, please estimate:

How your performance (alertness, memory, attention) would be affected...	1 Not at all Impaired	2	3	4	5	6	7 Severely Impaired	n/a
On the **first** day of the 42-day duty cycle in **non-icebreaking** operations (i.e., transit, port)	❑	❑	❑	❑	❑	❑	❑	❑
On the **first** day of the 42-day duty cycle in **icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑
On the **last** day of the 42-day duty cycle in **non-icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑
On the **last** day of the 42-day duty cycle in **icebreaking** operations	❑	❑	❑	❑	❑	❑	❑	❑

2. Please record the total estimated daily sleep you obtain, on average, over a 24 hour period, under the following conditions.

Estimated daily sleep (in hours)

	0-3	4	5	6	7	8	>8
at beginning of 28-day duty cycle	❑	❑	❑	❑	❑	❑	❑
near end of duty cycle	❑	❑	❑	❑	❑	❑	❑
during non-icebreaking operations	❑	❑	❑	❑	❑	❑	❑
during icebreaking operations	❑	❑	❑	❑	❑	❑	❑
when on day shift	❑	❑	❑	❑	❑	❑	❑
when on night shift	❑	❑	❑	❑	❑	❑	❑
during first few days after duty cycle	❑	❑	❑	❑	❑	❑	❑
typical day off	❑	❑	❑	❑	❑	❑	❑

3. The following questions will help us define your overall state of health. How often do you:

	1 Never	2	3	4	5	6	7 Always
feel fit and healthy?	❑	❑	❑	❑	❑	❑	❑
fall asleep easily?	❑	❑	❑	❑	❑	❑	❑
wake up easily?	❑	❑	❑	❑	❑	❑	❑
sleep well through the night?	❑	❑	❑	❑	❑	❑	❑
sleep well through the day?	❑	❑	❑	❑	❑	❑	❑
feel moody, or grumpy?	❑	❑	❑	❑	❑	❑	❑
feel tired and drained of energy?	❑	❑	❑	❑	❑	❑	❑
feel short of breath?	❑	❑	❑	❑	❑	❑	❑
suffer from constipation or diarrhea?	❑	❑	❑	❑	❑	❑	❑
feel your heart racing or skipping?	❑	❑	❑	❑	❑	❑	❑
have headaches?	❑	❑	❑	❑	❑	❑	❑
momentarily freeze on the job when you are extremely tired?	❑	❑	❑	❑	❑	❑	❑
find your appetite disturbed?	❑	❑	❑	❑	❑	❑	❑
suffer from heartburn/ indigestion/ stomach-ache?	❑	❑	❑	❑	❑	❑	❑
feel nauseous?	❑	❑	❑	❑	❑	❑	❑
feel dizzy?	❑	❑	❑	❑	❑	❑	❑
engage in regular physical exercise?	❑	❑	❑	❑	❑	❑	❑
experience lapses in your attention?	❑	❑	❑	❑	❑	❑	❑
eat at least 2 nutritious daily meals?	❑	❑	❑	❑	❑	❑	❑

Shiftwork

1. In this section we would like to obtain information on how people use different methods to cope with shiftwork and layday cycles. Which of the following methods do you practice?

To help cope with shiftwork and layday cycles, I...

	Never 1	2	3	4	5	6	Always 7
try to get an adequate amount of sleep daily	❑	❑	❑	❑	❑	❑	❑
nap off-duty to catch up on sleep	❑	❑	❑	❑	❑	❑	❑
take a short walk to get some fresh air	❑	❑	❑	❑	❑	❑	❑
drink water at work when I am tired	❑	❑	❑	❑	❑	❑	❑
drink coffee, tea or cola to perk me up	❑	❑	❑	❑	❑	❑	❑
put up with fatigue until it passes	❑	❑	❑	❑	❑	❑	❑
go for a smoke when I feel tired on duty	❑	❑	❑	❑	❑	❑	❑
exercise regularily on duty	❑	❑	❑	❑	❑	❑	❑
avoid alcohol	❑	❑	❑	❑	❑	❑	❑
eat nutritiously each day	❑	❑	❑	❑	❑	❑	❑
take vitamins, health supplements, etc.	❑	❑	❑	❑	❑	❑	❑
read in bed to fall asleep	❑	❑	❑	❑	❑	❑	❑
keep cabin as dark as possible while I sleep	❑	❑	❑	❑	❑	❑	❑
take a hot shower or bath	❑	❑	❑	❑	❑	❑	❑
take sleeping pills to fall asleep	❑	❑	❑	❑	❑	❑	❑
drink alcoholic beverages	❑	❑	❑	❑	❑	❑	❑
perform relaxation exercises or yoga	❑	❑	❑	❑	❑	❑	❑
have a smoke to relax off duty	❑	❑	❑	❑	❑	❑	❑
watch TV to relax	❑	❑	❑	❑	❑	❑	❑
take some time to just be alone	❑	❑	❑	❑	❑	❑	❑
spend recreation time with ship mates	❑	❑	❑	❑	❑	❑	❑
OTHER(S): (specify)____________________________	❑	❑	❑	❑	❑	❑	❑
____________________________							

2. Please indicate how much you agree with the following statements...

I am satisfied with...	strongly agree 1	2	3	4	5	6	strongly disagree 7
the kind of work I do	❑	❑	❑	❑	❑	❑	❑
the job as a whole (e.g., work environment)	❑	❑	❑	❑	❑	❑	❑
the shift type I work (e.g., 6&6, 4&8, 12&12)	❑	❑	❑	❑	❑	❑	❑
the crewing cycle I work (e.g., layday, conventional)	❑	❑	❑	❑	❑	❑	❑

5. Comments/ Questions

APPENDIX A2

Informed Consent Form

Disclaimer: The Informed Consent Form has been prepared for the School of Kinesiology, Simon Fraser University in the name of Laurel Ritmiller, a current M.Sc. student. At this point, the individual applying for ethics approval and the institution at which the application will be submitted is yet to be determined. This is merely an example of the items to be included in the Informed Consent Form for this study.

Informed Consent Form

Simon Fraser University and those conducting this project subscribe to the ethical conduct of research and to the protection at all times of the interests, comfort and safety of subjects. This form and the information it contains are given to you for your own protection and full understanding of the procedures associated with the project. Your signature on this form will signify that you have been informed of the procedures of this research project that you have received an adequate opportunity to consider this information, and that you voluntarily agree to participate in the project.

Having been asked by **Laurel Ritmiller** of the **School of Kinesiology, Simon Fraser University** to participate in a research project entitled, **Extended Crewing Periods during Arctic Icebreaking Operations, SSC File No. XSD95-00074-(671) /A),** I have been informed of the procedures specified in the document.

I understand the procedures and personal risks which are involved with this experiment. These personal risks are considered to be associated with use of the Nightcap and include: skin irritation related to use of the electrode; an allergic reaction to the adhesive used with the electrode; or eye irritation in the remote event that the electrode becomes detached from the eyelid or face. A risk considered to be associated with the tympanic temperature probe is the possibility of a brief sharp pain when the probe contacts the tympanic membrane. There is also the very slim possibility of puncturing the ear drum.

I understand that I may withdraw my participation in this experiment at any time or may choose not to perform certain procedures involved with this experiment.

I also understand that I may register any complaint I might have about the experiment with the chief researcher named above or with Dr. A. Hoffer, Director of Kinesiology at Simon Fraser University.

I may obtain copies of the results of this study, upon its completion, by contacting Laurel Ritmiller c/o BCRI, 3650 Wesbrook Mall, Vancouver, B.C. V6S 2L2. (tel: 604-224-4331).

I have been informed that the research material will be held in confidence by the principal investigator.

I agree to participate by:

- completing a general history questionnaire and personality inventory
- completing a subjective assessment of environmental conditions
- completing a questionnaire regarding medication which may be related to shift work
- completing sleep/activity logs each day of the crewing cycle (bridge and engine room watchkeepers only)
- completing subjective assessment questionnaires before, during and after my shift (bridge and engine room watchkeepers only)
- performing computer based cognitive tasks before, during and after my shift (bridge and engine room watchkeepers only)
- wearing an activity monitoring device (PAM2) for the duty cycle (bridge and engine room watchkeepers only)
- wearing an oculometry (eye blinks) monitoring device (Nightcap) for limited periods of time during the duty cycle (bridge and engine room watchkeepers only)
- providing tympanic temperature readings at six points per day on specified days during the crewing cycle (bridge and engine room watchkeepers only)
- being videotaped while performing my on-bridge duties for limited periods of time during the duty cycle (bridge and engineering watchkeepers only)
- participating in crew debriefings at the end of the duty cycle

during the period: ________________________ at (please circle one) (Quebec City, PQ or Victoria, B.C.)

NAME (please print): ____

ADDRESS: ____

____

SIGNATURE: ________________________________ WITNESS: __________________________

DATE: ____________________

Once signed, a copy of this consent form will be provided to you.

APPENDIX A3

Medication Information Questionnaire

Medication Information

1. Do you take any prescription or non-prescription medication on a regular basis?
   yes ❑ no ❑

   If yes:

   For what condition(s)? ______________________________

   ____

   What type(s)? ______________________________

   ____

2. Do you have any other medical problems on an on-going basis (i.e.: hypertension, epilepsy, diabetes)?
   yes ❑ no ❑

   If yes, please describe: ______________________________

   ____

3. Do you routinely take to sea any other prescription or non-prescription medication (i.e.: caffeine pills, sleeping pills, acetomenophine)?
   yes ❑ no ❑

   If yes, what type(s): ______________________________

APPENDIX A4

Personality Inventory

Eysenck Personality Inventory

Personality type is known to be related to ability to cope with shiftwork. The following is a personality inventory that will provide information on your personality type.

Circle YES or NO if the question applies to you.

1.	Do you often long for excitement?	YES	NO
2.	Do you often need understanding friends to cheer you up?	YES	NO
3.	Are you usually carefree?	YES	NO
4.	Do you find it hard to take no for an answer?	YES	NO
5.	Do you stop and think things over before doing anything?	YES	NO
6.	If you say you will do something do you always keep your promise, no matter how inconvenient it might be to do so?	YES	NO
7.	Does your mood often go up and down?	YES	NO
8.	Do you generally do and say things quickly without stopping to think?	YES	NO
9.	Do you ever feel "just miserable" for no good reason?	YES	NO
10.	Would you do almost anything for a dare?	YES	NO
11.	Do you suddenly feel shy when you want to talk to an attractive stranger?	YES	NO
12.	Once in a while do you lose your temper and get angry?	YES	NO
13.	Do you often do things on the spur of the moment?	YES	NO
14.	Do you often worry about things you should have not done or said?	YES	NO
15.	Generally do you prefer reading to meeting people?	YES	NO
16.	Are your feelings rather easily hurt?	YES	NO
17.	Do you like going out a lot?	YES	NO
18.	Do you occasionally have thoughts and ideas that you would not like other people to know about?	YES	NO
19.	Are you sometimes bubbling over with energy and sometimes very sluggish?	YES	NO
20.	Do you prefer to have few but special friends?	YES	NO
21.	Do you daydream a lot?	YES	NO
22.	When people shout at you do you shout back?	YES	NO
23.	Are you often troubled by feelings of guilt?	YES	NO
24.	Are all your habits good and desirable ones?	YES	NO
25.	Can you usually let yourself go and enjoy yourself at a party?	YES	NO
26.	Would you call yourself tense or "high-strung"?	YES	NO
27.	Do other people think of you as being very lively?	YES	NO

28.	After you have done something important, do you often come away feeling you could have done better?	YES	NO
29.	Are you mostly quiet when you are with other people?	YES	NO
30.	Do you sometimes gossip?	YES	NO
31.	Do ideas run through your head so that you cannot sleep?	YES	NO
32.	If there is something that you want to know about, would you rather look it up in a book than talk to someone about it?	YES	NO
33.	Do you get palpitations or thumping in your heart?	YES	NO
34.	Do you like to get the kind of work that you need to pay close attention to?	YES	NO
35.	Do you get attacks of shaking and trembling?	YES	NO
36.	Would you always declare everything at customs, even if you knew that you could never be found out?	YES	NO
37.	Do you hate being with a crowd who play jokes on one another?	YES	NO
38.	Are you an irritable person?	YES	NO
39.	Do you like doing things in which you have to act quickly?	YES	NO
40.	Do you worry about awful things that might happen?	YES	NO
41.	Are you slow and unhurried in the way you move?	YES	NO
42.	Have you ever been late for an appointment or work?	YES	NO
43.	Do you have many nightmares?	YES	NO
44.	Do you like talking to people so much that you would never miss a chance of talking to a stranger?	YES	NO
45.	Are you troubled by aches and pains?	YES	NO
46.	Would you be very unhappy if you could not see lots of people most of the time?	YES	NO
47.	Would you call yourself a nervous person?	YES	NO
48.	Of all the people you know are there some whom you definitely do not like?	YES	NO
49.	Would you say you are fairly self-confident?	YES	NO
50.	Are you easily hurt when people find fault with you or your work?	YES	NO
51.	Do you find it hard to really enjoy yourself at a lively party?	YES	NO
52.	Are you troubled with feeling of inferiority?	YES	NO
53.	Can you easily get some life into a rather dull party?	YES	NO
54.	Do you sometimes talk about things you know nothing about?	YES	NO
55.	Do you worry about your health?	YES	NO
56.	Do you like playing pranks on others?	YES	NO
57.	Do you suffer from sleepiness?	YES	NO

Shiftwork Questionnaire

For each question, please check the box next to the answer which best describes you.

1.	Considering only your own "feeling best" rhythm, at what time would you get up if you were entirely free to plan your day?	☐ 05.00-06.30 a.m. ☐ 06.30-07.45 a.m. ☐ 07.45-09.45 a.m. ☐ 09.45-11.00 a.m. ☐ 11.00 a.m.-12.00 (noon)
2.	Considering only your own "feeling best" rhythm, at what time would you go to bed if you were entirely free to plan your evening?	☐ 08.00-09.00 p.m. ☐ 09.00-10.15 p.m. ☐ 10.15 p.m.-12.30 a.m. ☐ 12.30-01.45 a.m. ☐ 01.45-3.00 a.m.
3.	Assuming normal circumstances, how easy do you find getting up in the morning?	☐ Not easy at all ☐ Slightly easy ☐ Fairly easy ☐ Very easy
4.	How alert do you feel during the first half hour after having awakened in the morning?	☐ Not at all alert ☐ Slightly alert ☐ Fairly alert ☐ Very alert
5.	During the first half hour after having awakened in the morning, how tired do you feel?	☐ Very tired ☐ Fairly tired ☐ Fairly refreshed ☐ Very refreshed
6.	You have decided to engage in some physical exercise. A friend suggests that you do this one hour twice a week and the best time for him is 7.00-8.00 a.m. Bearing in mind nothing else but your own "feeling best" rhythm, how do you think you would perform?	☐ Would be in good form ☐ Would be in reasonable form ☐ Would find it difficult ☐ Would find it very difficult
7.	At what time in the evening do you feel tired, and as a result, in need of sleep?	☐ 08.00-09.00 p.m. ☐ 09.00-10.15 p.m. ☐ 10.15 p.m.-12.30 a.m. ☐ 12.30-01.45 a.m. ☐ 01.45-03.00 a.m.

8.	You wish to be at your peak performance for a test which you know is going to be mentally exhausting and lasting for two hours. You are entirely free to plan your day, and considering only your own "feeling best" rhythm, which ONE of these four testing times would you choose?	☐ 08.00-10.00 a.m. ☐ 11.00 a.m.-1.00 p.m. ☐ 03.00 p.m.-05.00 p.m. ☐ 07.00-09.00 p.m.
9.	One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?	☐ Definitely a morning type ☐ Definitely an evening type ☐ More an evening than morning type ☐ More a morning type than evening type
10.	When would you prefer to rise (provided you have a full day's work - 8 hours) if you were totally free to arrange your time?	☐ Before 06.30 a.m. ☐ 06.30-07.30 a.m. ☐ 07.30-08.30 a.m. ☐ 08.30 a.m. or later
11.	If you always had to rise at 06.00 a.m., what do you think it would be like?	☐ Very difficult ☐ Rather difficult and unpleasant ☐ A little unpleasant but no great problem ☐ Easy and not unpleasant
12.	How long a time does it usually take before you "recover your senses" in the morning after rising from a night's sleep?	☐ 0-10 minutes ☐ 11-20 minutes ☐ 21-40 minutes ☐ More than 40 minutes
13.	Please indicate to what extent you are a morning or evening *active* individual?	☐ Pronounced morning active (morning alert and evening tired) ☐ To some extent, morning active ☐ To some extent evening active ☐ Pronounced evening active (morning tired and evening alert)

The following questions are concerned with your daily habits and preferences. Please indicate what you prefer to do, or can do, and not what you may be forced to do by your present work schedule or routine.

Please work though the questions as quickly as possible. It is your immediate reaction to the questions that we are interested in, rather than a carefully deliberated answer. There are no "right" or "wrong" answers to any of the questions. For each question we simply want you to indicate which of the five alternatives best describes you, or your preferences, by circling the appropriate number.

		Almost Never	Seldom	Some-times	Usually	Almost Always
1.	Do you tend to need more sleep than other people?	1	2	3	4	5
2.	If you are feeling drowsy can you easily overcome it if you have something to do?	1	2	3	4	5
3.	Do you find it fairly easy to get sleep whenever you want it?	1	2	3	4	5
4.	Can you miss a night's sleep without too much difficulty?	1	2	3	4	5
5.	Do you find it easy to "wake-up" properly if you are awoken at an unusual time?	1	2	3	4	5
6.	If you had to do a certain job in the middle of the night do you think you could do it almost as easily as at a more normal time of the day?	1	2	3	4	5
7.	Do you find it easy to "sleep in" in the morning if you got to bed very late the previous night?	1	2	3	4	5
8.	If you go to bed very late do you need to "sleep in" the following morning?	1	2	3	4	5
9.	Can you easily keep alert in boring situations?	1	2	3	4	5
10.	Are you fairly unaware as to what time it is?	1	2	3	4	5
11.	If you are tired, do you have difficulty keeping awake even though you need to?	1	2	3	4	5
12.	Do you enjoy working at unusual times of the day or night?	1	2	3	4	5
13.	Do you feel sleepy for a while after waking in the morning?	1	2	3	4	5
14.	Do you get up later than normal when you are on holiday?	1	2	3	4	5

		Almost Never	Seldom	Some-times	Usually	Almost Always
15.	If you have a lot to do can you stay up late to finish it off without feeling too tired?	1	2	3	4	5
16.	Does the time of day have a large effect on your mood and abilities?	1	2	3	4	5
17.	Do you find it as easy to work late at night as earlier in the day?	1	2	3	4	5
18.	If you have to get up very early one morning do you tend to feel tired all day long?	1	2	3	4	5
19.	Do you "nod-off" if you are listening to, or watching, a boring program?	1	2	3	4	5
20.	Can you easily go to sleep earlier than normal to "catch up" on lost sleep (e.g., after several late nights)?	1	2	3	4	5
21.	Do you have no strong preference as to when you sleep?	1	2	3	4	5
22.	Can you manage with only a few hours sleep each night for several days in a row without too much difficulty?	1	2	3	4	5
23.	Do you find it fairly difficult to overcome tiredness even in a challenging situation?	1	2	3	4	5
24.	Would you be just as happy to do something in the middle of the night as during the day?	1	2	3	4	5
25.	Do you rely on an alarm clock, or someone else, to wake you up in the morning?	1	2	3	4	5
26.	Do you get to sleep fairly quickly when you have gone to bed earlier than normal?	1	2	3	4	5
27.	Do you go to parties, or have evenings out with friends, if you have to get up early the following morning?	1	2	3	4	5
28.	Do you need a cup of coffee or tea to wake up properly after you have been asleep?	1	2	3	4	5
29.	Are there particular times of the day when you would avoid doing certain jobs if you could?	1	2	3	4	5
30.	If you could do so, would you rather wait for a half-an hour or so after waking in the morning before eating a large breakfast?	1	2	3	4	5

APPENDIX A5

Subjective Workload Assessment

Subjective Workload Assessment Questionnaire

Workload has to do with the requirements of your job and the level of effort needed to perform your job. Workload is affected by characteristics of the job itself, your physical and mental state and characteristics of the surrounding environment. Workload can be divided into a number of components, as indicated below. For each of the following workload components, please circle the appropriate number to describe the workload <u>you experienced</u> in the shift you just completed.

MENTAL DEMAND
How much mental effort was required (e.g. thinking, deciding, calculating, remembering, etc.)?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

VISUAL DEMAND
How much visual effort was required (e.g. looking, searching, etc.)?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

PHYSICAL DEMAND
How much physical effort was required (e.g. pushing, pulling, turning, etc.)?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

TEMPORAL DEMAND
How much time pressure did you feel due to the pace of work?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

PERFORMANCE
How satisfied were you with your performance in accomplishing goals?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Poor Neutral Good

EFFORT
How hard did you have to work (mentally and physically) to accomplish your level of performance?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

FRUSTRATION LEVEL
What level of frustration did you feel when completing tasks?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

Taking into consideration all of the preceding workload components you just rated, as well as any additional factors you feel may be relevant, please circle the number below which best describes the overall level of workload you experienced during your shift.

OVERALL WORKLOAD LEVEL

What was your overall level of effort to complete this task?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

RELATIVE WORKLOAD LEVEL

In relation to other shifts during the same hours and with the same responsibilities, how would you rate the overall level of workload you experienced in the preceding shift.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Much Lower Same Much Higher

Please perform the DELTA tests NOW.

Remember to update your Sleep/Activity Log.

APPENDIX A6

Subjective Performance Assessment Questionnaire

Pre-Shift Assessment Questionnaire

Since the end of your last shift:

1. Did you take any medication? yes ❑ no ❑
   If yes, for what condition?____________________________
   If yes, what type? ____________________________________

2. Did you try to (or want to) sleep? yes ❑ no ❑
   If no, go to Question 3
   If yes, did you have any problems? yes ❑ no ❑
   a. quality of sleep was... normal ❑ poor ❑ awful ❑
   b. duration of sleep was... normal ❑ short ❑ zero ❑
   c. the problems were caused by:
   ship motions (had to hold on) yes ❑ no ❑
   other (e.g. extra duty, environmental conditions): __________________________

3. Please rate the severity of the following symptoms right now.

where, 0=not at all, 1=a little, 2=somewhat 3=quite a bit, and 4=extremely	0	1	2	3	4
general discomfort (feel lousy)	❑	❑	❑	❑	❑
stomach awareness	❑	❑	❑	❑	❑
headache	❑	❑	❑	❑	❑
yawning	❑	❑	❑	❑	❑
physical fatigue	❑	❑	❑	❑	❑
mental fatigue	❑	❑	❑	❑	❑
drowsy	❑	❑	❑	❑	❑
apathy	❑	❑	❑	❑	❑
tension/anxiety	❑	❑	❑	❑	❑
dizziness	❑	❑	❑	❑	❑
steadiness	❑	❑	❑	❑	❑

4. Did you notice any other problems since your last shift? yes ❑ no ❑
   If no, go to "Comments" section.
   If yes, did you experience problems with:

where, 0=not at all, 1=a little, 2=somewhat 3=quite a bit, and 4=extremely	0	1	2	3	4
air quality	❑	❑	❑	❑	❑
too hot	❑	❑	❑	❑	❑
too cold	❑	❑	❑	❑	❑
noise	❑	❑	❑	❑	❑
vibration	❑	❑	❑	❑	❑
lighting	❑	❑	❑	❑	❑
other problem or illness	❑	❑	❑	❑	❑
describe: ________________________________					

Comments:

Post-Shift Assessment Questionnaire

1. Please describe the general location of your work area.

____

____

2. Please provide a general description of the tasks you completed during your shift.

____

____

3. Please rate the severity of the following symptoms <u>right now</u>.

where, 0=not at all, 1=a little, 2=somewhat 3=quite a bit, and 4=extremely	0	1	2	3	4
general discomfort (feel lousy)	❑	❑	❑	❑	❑
stomach awareness	❑	❑	❑	❑	❑
headache	❑	❑	❑	❑	❑
yawning	❑	❑	❑	❑	❑
physical fatigue	❑	❑	❑	❑	❑
mental fatigue	❑	❑	❑	❑	❑
drowsy	❑	❑	❑	❑	❑
apathy	❑	❑	❑	❑	❑
tension/anxiety	❑	❑	❑	❑	❑
dizziness	❑	❑	❑	❑	❑
steadiness	❑	❑	❑	❑	❑

4. Was your task performance degraded or impaired due to fatigue or time of day?

   yes ❑ no ❑

   If no, go to Question 5.

   If yes then,

where, 0=not at all, 1=a little, 2=somewhat 3=quite a bit, and 4=extremely	0	1	2	3	4
how severe was the performance degradation?	❑	❑	❑	❑	❑

5. Was your mental performance degraded or impaired due to fatigue or or time of day?

   yes ❑ no ❑

   If no, go to Question 6.

   If yes, then...

where, 0=not at all, 1=a little, 2=somewhat 3=quite a bit, and 4=extremely	0	1	2	3	4
trouble making decisions	❑	❑	❑	❑	❑
trouble with memory	❑	❑	❑	❑	❑
trouble with simple tasks (adding, spelling, etc.)	❑	❑	❑	❑	❑
trouble concentrating or maintaining attention	❑	❑	❑	❑	❑
general apathy	❑	❑	❑	❑	❑
other: ____________________	❑	❑	❑	❑	❑

6. Was your physical performance degraded or impaired due to fatigue or seasickness?

yes ❑ no ❑

If no, go to Question 7.

If yes, did this result from...

where, 0=not at all, 1=a little, 2=somewhat 3=quite a bit, and 4=extremely	0	1	2	3	4
body/ship motions (had to hold on)	❑	❑	❑	❑	❑
problems with vision	❑	❑	❑	❑	❑
feeling weak or shaky	❑	❑	❑	❑	❑
other: ____________________________	❑	❑	❑	❑	❑

7. How was your task completion affected by fatigue? (check one)

not affected, tasks completed in normal time	❑
tasks completed, but took longer than normal	❑
tasks not completed in time available	❑
had to abandon tasks	❑
was not able to attempt tasks	❑

8. Did you notice any other problems? yes ❑ no ❑

If no, go to "Comments" section.

If yes, did you experience problems with:

where, 0=not at all, 1=a little, 2=somewhat 3=quite a bit, and 4=extremely	0	1	2	3	4
air quality	❑	❑	❑	❑	❑
too hot	❑	❑	❑	❑	❑
too cold	❑	❑	❑	❑	❑
noise	❑	❑	❑	❑	❑
vibration	❑	❑	❑	❑	❑
lighting	❑	❑	❑	❑	❑
other problem or illness	❑	❑	❑	❑	❑
describe: ________________________________					

Comments:

APPENDIX A7

Situational Awareness Questionnaire

Situational Awareness Assessment

In a dynamic or changing task environment, the ability to perform your job is directly related to knowledge of the present situation, past developments, and possible future task requirements. This type of knowledge is referred to as situational awareness. Using the scale provided below, please rate your situational awareness at this point in time by circling the appropriate level. Be as objective and as honest as possible in making your response.

Degree of Situational Awareness:

|__________|__________|__________|__________|__________|__________|

Low Medium High

APPENDIX A8

Sleep/Activity Log

Sleep/Activity Log

The following log is designed to record details on your work, sleep and leisure activities during your duty cycle. Using the legend provided, please record your activities on a daily basis in as much detail as possible. An example of how to fill out the log is provided below.

Legend

Work Activities

[ ] Bracket regularly scheduled work hours
O Overtime work hours
R Rest periods at work (e.g. lunch, breaks)

Sleep Activities

↓ mark "down" arrow each time you got in bed
↑ mark "up" arrow each time you got out of bed
| mark the times you began and ended your sleep; then join the lines
P Use of toilet during sleep time
N Noises that disturb your sleep
W Time of wake up call or alarm (if any)

Leisure Activities

L Leisure time alone (e.g. TV, hobby, etc.)
F Leisure time with others (co-workers, etc.) (playing cards, movie, etc.)
D Domestic work (personal hygeine, laundry, etc.)
E Physical exercise

M Meals
S Snacks
C Each caffienated drink (tea, coffee, cola)
A Each alcoholic drink (beer, wine, etc.)
T Use of tobacco (e.g. cigarette, cigar, chewing tobacco)

Example

During your sleep from the night before, a noise woke you up at 0100h, used the toilet at 0300h and got out of bed at 0600h. Your shift began at 0800h and was scheduled to end at 2000h, but you worked two hours of overtime. You ate at 0700h (with a caffeinated drink), and 1200h. You had a snack at 2200h and exercised at 2230. You went to bed at 2400h, and went to sleep at 2430h . Information after midnight is on tomorrow's log.

Date: _________

000h 0200h 0400h 0600h 0800h 1000h 1200h 1400h 1600h 1800h 2000h 2200h 2400h

Work																								
Sleep																								
Leisure																								

Date: _________

000h 0200h 0400h 0600h 0800h 1000h 1200h 1400h 1600h 1800h 2000h 2200h 2400h

Work																								
Sleep																								
Leisure																								

Please indicate the overall quality of your sleep:

1 2 3 4 5 6 7
Poor Fair Excellent

APPENDIX A9

Commanding Officer's Assessment of Crew Fatigue

Crew Workload and Fatigue

Please rate the overall workload of your crew and the overall level of fatigue of your crew after each shift.

Day 1

1. Workload has to do with the requirements of the job and the level of effort needed to perform the job effectively. Workload is affected by variables including task characteristics, physical and mental state as well as characteristics of the surrounding environment. Taking into consideration these workload components, as well as any additional factors you feel may be relevant, please circle the number below which best describes the overall level of workload of the bridge crew during their most recent shift.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

2. Based of your observations of the bridge crew during their most recent shift, please circle the number below which you feel best describes their overall level of fatigue.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

Day 2

1. Workload has to do with the requirements of the job and the level of effort needed to perform the job effectively. Workload is affected by variables including task characteristics, physical and mental state as well as characteristics of the surrounding environment. Taking into consideration these workload components, as well as any additional factors you feel may be relevant, please circle the number below which best describes the overall level of workload of the engineering crew during their most recent shift.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

2. Based of your observations of the engineering crew during their most recent shift, please circle the number below which you feel best describes their overall level of fatigue.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

APPENDIX A10

Mood Assessment Questionnaire

Mood Assessment Questionnaire

Please indicate your level on each of the following measures right now.

1. Overall alertness

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

2. Overall cheerfulness

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

3. Overall calmness

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

4. Overall irritability

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

5. Overall level of confidence

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

6. Overall feeling of withdrawl

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Low Medium High

APPENDIX A11

Socio-psychological Questionnaire: Group Dynamics and Team Cohesion Questionnaire

Team Cohesion Questionnaire

Fatigue impacts on mood, which affects motivation and subsequently task performance and crew dynamics. The purpose of this questionnaire is to assess group dynamics, morale and team cohesion within a crew during CCG operations.

In the following questionnaire, "crew" refers only to the team with which you are working during your watch (i.e., engine room crew or bridge crew). The "vessel crew" refers to everyone on the vessel during operations.

Circle the area in which you work: engine room bridge

Part 1: Group Dynamics and Morale

Please rate the following statements according to the scale:

		Not at all	A little	Somewhat	Quite a bit	Extremely
1.	I am confident in the skills and abilities of other crew members	0	1	2	3	4
2.	It feels good to be part of my crew	0	1	2	3	4
3.	The level of morale in my crew is very high	0	1	2	3	4
4.	I am satisfied with the social events on board my vessel	0	1	2	3	4
5.	The members of my crew are proud to be part of the vessel's crew	0	1	2	3	4
6.	My job is important to the vessel's operations	0	1	2	3	4
7.	I am confident in my abilities and skills in the job I perform for CCG	0	1	2	3	4

Please rate the following statements according to the scale:

		Never	Sometimes	Usually	Often	Always
8.	Members of my crew know what is expected of them	0	1	2	3	4
9.	I would rather work with my crew during CCG operations than with any other crew I know	0	1	2	3	4
10.	My personal level of morale is very high	0	1	2	3	4
11.	The members of my crew encourage each other to work together as a team	0	1	2	3	4
12.	There is a lot of togetherness in my crew	0	1	2	3	4
13.	My supervisor offers new ideas for solving job related problems	0	1	2	3	4
14.	My supervisor is willing to listen to any problems (not just job related)	0	1	2	3	4
15.	My supervisor makes sure his/her role in vessel operations is understood by other crew members	0	1	2	3	4

Part 2: Stressors during CCG Operations

The following stressors have been identified by people working in similar operations as required during Arctic icebreaking operations. In YOUR life right now, how much trouble or concern is caused by:

	None	A Little	Some	Quite a bit	Very much
1. Being unable to deal with problems when they occur back home	0	1	2	3	4
2. Feeling isolated or trapped in one location	0	1	2	3	4
3. A lack of privacy	0	1	2	3	4
4. Living in close quarters with so many people	0	1	2	3	4
5. Not having a place to be by yourself	0	1	2	3	4
6. Insufficient personnel to complete the tasks assigned	0	1	2	3	4
7. Loneliness	0	1	2	3	4
8. A lack of contact with family/friends back home	0	1	2	3	4
9. Adjusting to a totally different environment	0	1	2	3	4
10. Boredom	0	1	2	3	4
11. Being separated from loved ones back home	0	1	2	3	4
12. Inadequate or insufficient equipment	0	1	2	3	4
13. Lack of time off	0	1	2	3	4
14. Fitting in with members of your crew	0	1	2	3	4
15. Being out of touch with what is going on back home	0	1	2	3	4
16. Uncomfortable living conditions	0	1	2	3	4
17. Slow or inefficient mail service	0	1	2	3	4
18. Adjusting to new working relationships	0	1	2	3	4
19. Worry over the welfare of your family	0	1	2	3	4
20. Too heavy a workload	0	1	2	3	4
21. A lack of adequate recreational opportunities during off hours	0	1	2	3	4
22. A lack of clear direction or orders necessary to carry out tasks	0	1	2	3	4

APPENDIX A12

Environmental Factors Questionnaire

Environmental Factors Questionnaire

Please indicate your **normal working area**:

☐ Bridge ☐ Engine room ☐ Other: ________________________

Please describe the location of your **sleeping quarters**: ________________________________

____

Overall, how would you rate your sleeping area in terms of it being conducive to sleep. Please circle the appropriate description below.

Poor — Fair — Good — Excellent

Please rate the following environmental factors by circling the appropriate number.

A. Noise

1. Level of general noise in your:

   a. **normal working area** during **non-icebreaking** activities:

1	2	3	4	5	6	7

Extremely Comfortable — Extremely Uncomfortable

   b. **normal working area** during **icebreaking** activities:

1	2	3	4	5	6	7

Extremely Comfortable — Extremely Uncomfortable

   c. **sleeping quarters** during **non-icebreaking** activities:

1	2	3	4	5	6	7

Extremely Comfortable — Extremely Uncomfortable

   d. **sleeping quarters** during **icebreaking** activities:

1	2	3	4	5	6	7

Extremely Comfortable — Extremely Uncomfortable

2. Do you experience engine noise in your **normal working area**?

   ☐ Yes ☐ No ☐ Sometimes

   If yes or sometimes, to what extent does this noise affect your work performance?

1	2	3	4	5	6	7

Not at all — A lot

3. Do you experience noise related to icebreaking in your **normal working area**?

☐ Yes ☐ No ☐ Sometimes

If yes or sometimes, to what extent does this noise affect your work performance?

1	2	3	4	5	6	7

Not at all A lot

4. Do you experience TV/radio noise in your **normal working area**?

☐ Yes ☐ No ☐ Sometimes

If yes or sometimes, to what extent does this noise affect your work performance?

1	2	3	4	5	6	7

Not at all A lot

5. Do you experience noise from other crew members talking/making noise in your **normal working area**?

☐ Yes ☐ No ☐ Sometimes

If yes or sometimes, to what extent does this noise affect your work performance?

1	2	3	4	5	6	7

Not at all A lot

6. Do you experience other equipment noise in your **normal working area**?

☐ Yes ☐ No ☐ Sometimes

If yes or sometimes, to what extent does this noise affect your work performance? (Please specify equipment: ____

1	2	3	4	5	6	7

Not at all A lot

7. Please describe any other sources of noise in your normal working area.

____

____

8. Do you experience engine noise in your **sleeping quarters**?

☐ Yes ☐ No ☐ Sometimes

If yes or sometimes, to what extent does this noise affect your sleep?

1	2	3	4	5	6	7

Not at all A lot

9. Do you experience noise related to icebreaking in your **sleeping quarters**?

☐ Yes ☐ No ☐ Sometimes

If yes or sometimes, to what extent does this noise affect your sleep?

1	2	3	4	5	6	7

Not at all A lot

10. Do you experience TV/radio noise in your **sleeping quarters**?

☐ Yes ☐ No ☐ Sometimes

If yes or sometimes, to what extent does this noise affect your sleep?

1	2	3	4	5	6	7

Not at all A lot

11. Do you experience noise from other crew members talking/making noise in your **sleeping quarters**?

☐ Yes ☐ No ☐ Sometimes

If yes or sometimes, to what extent does this noise affect your sleep?

1	2	3	4	5	6	7

Not at all A lot

12. Do you experience other equipment noise in your **sleeping quarters**?

☐ Yes ☐ No ☐ Sometimes

If yes or sometimes, to what extent does this noise affect your sleep? (Please specify equipment: ______________________________

1	2	3	4	5	6	7

Not at all A lot

13. Please describe any other sources of noise in the area of your sleeping quarters.

____

____

14. In your **normal working area**, does noise interfere with verbal communication with other crew members?

1	2	3	4	5	6	7

Never Always

15. Do you wear hearing protection while in your **normal working area**?

1	2	3	4	5	6	7

Never Always

16. Do you wear hearing protection while **sleeping** in your quarters?

1	2	3	4	5	6	7

Never Always

17. Do you experience any problems (i.e., headaches, ringing in the ears) which you feel may be related to noise?

1	2	3	4	5	6	7

Never Always

Describe: ____

____

B. Lighting

1. Please indicate the level of general lighting in your **normal working area**:

1	2	3	4	5	6	7

Extremely Comfortable Extremely Uncomfortable

2. Please indicate the level of glare from lighting in your **normal working area**:

1	2	3	4	5	6	7

Extremely Comfortable Extremely Uncomfortable

If yes, please describe the sources of glare in your working area: ________________

____

3. Do you have windows in your **normal working area**.

☐ yes ☐ no

If no, go to next question.

If yes:

Does outside lighting (i.e., sunlight) interfere with your vision.

1	2	3	4	5	6	7

Never Always

Describe: ____

____

4. Do you experience any problems (i.e., headaches, sore eyes) which you feel may be related to lighting problems?

1	2	3	4	5	6	7

Never Always

Describe: ____

____

C. Temperature and Humidity

1. Please indicate the level of general temperature in your **normal working area**:

1	2	3	4	5	6	7

Too cold Too hot

2. Please indicate the level of general temperature in your **sleeping area**:

1	2	3	4	5	6	7

Too cold Too hot

3. Please indicate the level of humidity in your **normal working area**:

1	2	3	4	5	6	7

Too dry Too humid

4. Please indicate the level of humidity in your **sleeping area**:

1	2	3	4	5	6	7

Too dry Too humid

5. Please indicate sources of **temperature** problems (i.e., direct drafts, heat produced from equipment), in your **normal working area**.

____

____

6. Please indicate sources of **temperature** problems (i.e., direct drafts, heat produced from equipment), in your **sleeping quarters**.

____

____

7. Please indicate sources of **humidity** problems (i.e., direct drafts, heat produced from equipment), in your **normal working area**.

____

____

8. Do you experience any problems (i.e., physical fatigue) which you feel may be related to temperature problems?

1	2	3	4	5	6	7

Never   Always

Describe: ____

____

APPENDIX B

Differences between the 28 and 42 Day Crewing Periods

Cognitive

Performance

Table B-1:
Weekly means and standard deviations (± sd) on the Delta tests for Groups 1 and 3. STM = short term memory; GR = grammatical reasoning; MP = mathematical processing; CRT = choice reaction time; SPC = successive pattern comparison; SP= spatial processing. Data are presented in terms of response time (RT - measured in seconds), accuracy (% correct), and rejections (number of times participants were rejected on tests because criterion performance levels were not attained). The number in brackets is the number of participants.

Performance: Delta

		Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
		Group1 (21)		Group3 (4)		Group1 (20)		Group3 (4)		Group1 (19)		Group3 (4)		Group1 (16)		Group3 (4)		Group1 (9)		Group3 (4)		Group1 (7)		Group3 (3)	
		Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd
STM	RT	0.90	0.18	0.98	0.17	0.81	0.16	0.90	0.21	0.82	0.23	0.84	0.14	0.77	0.17	0.84	0.16	0.77	0.15	0.88	0.14	0.74	0.17	0.99	0.26
	% Correct	96.76	1.52	95.35	3.97	97.16	1.82	97.74	1.78	96.88	2.26	96.81	2.09	96.95	2.28	97.48	2.88	97.37	1.62	96.97	3.10	97.47	1.59	98.31	1.36
GR	RT	3.64	0.77			3.37	0.77			3.30	0.84			3.40	0.70										
	% Correct	86.44	8.96			90.77	9.82			91.92	7.25			90.38	7.98										
MP	RT*	2.53	0.53	2.45	0.30	2.22	0.54	2.30	0.18	2.17	0.52	2.28	0.23	2.05	0.58	2.39	0.23	1.78	0.40	2.30	0.25	1.59	0.35	2.15	0.22
	% Correct*	93.87	3.90	94.47	4.08	95.89	2.41	96.33	0.71	96.97	2.68	97.58	1.79	96.16	2.78	96.91	1.11	96.37	1.88	97.52	1.73	96.97	1.70	97.08	5.06
SP	RT*	2.49	0.26	2.57	0.26	2.02	0.29	2.25	0.34	1.93	0.34	2.21	0.35	1.80	0.25	2.16	0.28	1.78	0.35	2.06	0.29	1.64	0.31	1.97	0.16
	% Correct**	90.18	8.04	88.03	6.75	96.35	3.06	96.70	1.63	96.48	2.83	96.14	3.43	97.55	2.22	97.04	2.55	97.76	1.72	96.34	3.33	96.51	2.80	97.56	4.23
SPC	RT	1.12	0.26	1.25	0.07	1.10	0.23	1.34	0.19	1.14	0.25	1.30	0.21	1.08	0.21	1.25	0.26	1.06	0.16	1.25	0.27	1.00	0.22	1.18	0.18
	% Correct	92.41	3.25	91.45	4.50	91.91	3.85	89.84	6.22	91.86	5.18	90.45	2.39	91.25	3.87	92.90	5.04	93.14	4.98	94.34	3.04	95.52	2.51	89.65	3.80
CRT	RT†	0.65	0.14	0.69	0.09	0.58	0.10	0.66	0.07	0.58	0.08	0.63	0.07	0.58	0.08	0.67	0.08	.55	.07	0.61	0.08	.54	.05	.61	0.08
	% Correct	99.38	0.59	99.57	0.87	98.64	1.26	98.47	1.86	98.43	1.88	99.61	0.38	99.04	0.94	99.17	1.67	99.05	0.82	98.92	1.29	99.08	0.99	99.76	0.42

* Significant effects for Group1 only
** Significant effects for Group1 and Group3
† Trend for Group1 only

Cognitive

Performance

Table B-2:
Weekly mean failure rates as expressed by percentage of failures (percentage of times participants were rejected on tests because criterion performance levels were not attained) on the Delta tests for Groups 1 and 3 combined. T=trials, F=failures. Number of participants is designated by n.

Performance: Delta Percentage of Failures

	Week																										
	Week 1				Week 2				Week 3				Week 4				Week 5				Week 6				Weeks 2-6		
Ship	n	#T	#F	% F	n	#T	#F	% F	n	#T	#F	% F	n	#T	#F	% F	n	#T	#F	% F	n	#T	#F	% F	Total #T	Total #F	% F
Radisson	9	138	30	21.74	9	106	1	0.94	9	83	1	1.20	8	73	2	2.74	9	63	3	4.76	6	29	0	0.00	354	7	1.98
Laurier	5	101	31	30.69	5	90	7	7.78	5	65	4	6.15	5	76	7	9.21	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	231	18	7.79
Total (Groups 1 and 3 combined)	14	239	61	25.52	14	196	8	4.08	14	148	5	3.38	13	149	9	6.04	9	63	3	4.76	6	29	0	0.00	679	29	4.27

Situational Awareness

Table B-3:
Weekly means and standard deviations (± sd) for situational awareness, for Groups 1 and 3. Data were scored on a 7-point scale, where: 1 = low; 4 = medium; and 7 = high situational awareness. The number in brackets is the number of participants.

Situational Awareness

	Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
	Group1 (21)		Group3 (6)		Group1 (21)		Group3 (6)		Group1 (18)		Group3 (6)		Group1 (16)		Group3 (6)		Group1 (9)		Group3 (4)		Group1 (9)		Group3 (3)	
	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd
Pre-watch	4.73	1.1	5.86	1.10	4.82	1.07	5.77	1.02	5.00	.95	5.62	1.15	4.99	1.15	5.67	1.21	4.99	1.11	5.84	.94	5.22	1.18	5.90	1.02
Post-watch	4.91	1.07	5.90	1.12	5.10	1.17	5.69	1.15	5.00	1.26	5.62	1.11	5.04	1.45	5.67	1.21	5.46	1.22	6.01	0.95	5.33	1.27	6.00	1.00

Cognitive

Subjective Workload

Table B-4:
Weekly means and standard deviations (± sd) for subjective workload for Groups 1 and 3. Data for each of the 7 dimensions of workload as well as for overall and relative workload were scored on separate 17-point scales, where: 1=low; 9=meduim and 17=high workload. The number in brackets is the number of participants.

Subjective Workload

	Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
	Group1 (22)		Group3 (6)		Group1 (21)		Group3 (6)		Group1 (17)		Group3 (6)		Group1 (16)		Group3 (6)		Group1 (9)		Group3 (4)		Group1 (9)		Group3 (3)	
	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd
Mental	9.50	2.29	10.51	1.85	10.02	2.48	11.02	2.04	9.12	2.59	11.12	2.00	8.89	1.69	10.19	2.83	9.06	1.09	11.40	2.26	9.9	1.75	12.04	2.38
Visual*	10.56	1.78	10.98	1.91	10.95	2.48	10.96	1.97	10.61	1.92	11.47	2.28	9.52	1.27	10.67	2.09	8.04	2.79	11.74	2.25	10.37	2.30	11.24	2.39
Physical	8.11	2.68	7.72	2.60	8.28	2.90	8.23	3.11	8.51	3.34	8.45	2.64	8.24	3.02	8.71	2.42	7.93	4.24	9.60	2.98	9.67	2.98	8.21	4.71
Temporal	7.52	3.34	8.79	4.20	8.90	2.85	9.77	2.41	8.43	2.52	10.83	1.21	8.68	2.63	8.51	2.18	8.97	2.93	7.75	3.62	10.25	2.26	6.68	4.93
Performance	11.96	2.08	11.78	2.29	11.64	2.25	11.28	1.82	11.30	2.69	11.15	1.34	10.69	2.45	10.94	1.46	9.96	2.27	10.55	1.67	10.90	3.10	11.70	1.21
Effort	9.55	2.07	8.67	3.38	9.50	2.57	9.60	3.19	9.07	2.73	10.24	1.39	9.10	2.19	9.69	2.02	9.51	2.95	9.21	3.72	10.20	2.25	6.96	5.29
Frustration	5.48	3.42	4.17	2.65	6.14	3.48	3.65	2.46	5.89	3.47	4.58	3.06	6.90	3.90	3.88	2.32	8.17	3.68	4.41	2.31	8.30	4.20	4.00	2.65
Overall	8.98	2.52	10.51	1.95	9.31	2.40	10.26	1.81	9.18	2.18	10.76	1.50	8.93	1.76	9.95	1.40	9.56	2.09	10.08	1.93	10.09	1.87	10.25	2.19
Relative	9.08	2.19	10.47	2.04	8.50	2.08	10.10	1.69	9.39	2.61	10.71	1.21	9.13	1.76	9.65	0.97	9.56	1.95	10.31	1.65	9.85	2.08	10.48	2.05

* Significant effects for Group1 only

Sleep

Sleep Duration and Quality (Activity Log and PAM/2)

Table B-5:
Weekly means and standard deviations (± sd) for sleep duration (minutes) and quality for Groups 1 and 3. Sleep quality was rated on a 7-point scale, where: 1=poor; 4=fair; and 7=excellent. The number in brackets is the number of participants.

Sleep Duration (Activity Log & Pam/2)

Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
Group1 (17)		Group3 (4)		Group1 (17)		Group3 (4)		Group1 (17)		Group3 (4)		Group1 (17)		Group3 (4)		Group1 (8)		Group3 (2)		Group1 (7)		Group3 (1)	
Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd
400.32	79.82	404.89	48.34	397.98	49.70	399.85	52.94	400.60	60.16	394.93	33.90	412.18	57.98	379.25	60.07	388.55	36.59	401.00	22.63	350.24	79.67	445.00	0.00

Sleep Quality (Activity Log)

Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
Group1 (17)		Group3 (4)		Group1 (17)		Group3 (4)		Group1 (17)		Group3 (4)		Group1 (17)		Group3 (4)		Group1 (8)		Group3 (2)		Group1 (7)		Group3 (1)	
Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd
4.57	1.23	4.40	0.53	4.73	1.02	4.63	0.58	4.62	0.93	4.09	0.22	4.76	1.42	4.29	0.34	4.69	1.10	3.92	0.83	4.98	0.93	5.00	0.00

Sleep

NightCap

Table B-6:
Means and standard deviations (± sd) on the NightCap for Days 11 to 28 and 29 to 42 for Group1 for: sleep efficiency (sleep duration (min.)/sleep period (min.), where sleep period=sleep duration plus time awake (min.); sleep latency (min.); and sleep duration (min.). Number of participants is designated by n.

NightCap

	Days 11 to 28			Days 29 to 42		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Sleep Duration	9	353.56	102.62	7	331.86	67.34
Sleep Latency	9	20.33	12.78	7	13.18	9.94
Sleep Efficiency	9	89.32	4.79	7	90.53	4.47

Fatigue

Subjective Assessment of Task and Mental Performance

Table B-7:
Weekly percentages of crew members indicating degraded task and mental performance for Groups 1 and 3. The initial response was either yes (Y) or no (N). The number in brackets is the number of participants.

Subjective Assessment of Task and Mental Performance

	Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
	Group1 (21)		Group3 (6)		Group1 (20)		Group3 (6)		Group1 (18)		Group3 (6)		Group1 (16)		Group3 (6)		Group1 (9)		Group3 (4)		Group1 (9)		Group3 (4)	
	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N
Degraded Task Performance	47.6	52.4	33.3	66.7	45.0	55.0	50.0	50.0	50.0	50.0	33.3	66.7	56.3	43.8	50.0	50.0	77.8	22.2	50.0	50.0	77.8	22.2	25.0	75.0
Degraded Mental Performance	45.5	54.5	33.3	66.7	47.6	52.4	33.3	66.7	57.9	42.1	50.0	50.0	56.3	43.8	33.3	66.7	55.6	44.4	50.0	50.0	77.8	22.2	25.0	75.0

Fatigue

Subjective Assessment of Mental Performance

Table B-8:
Weekly means and standard deviations (± sd) on 5 dimensions of mental performance for participants indicating performance degradation. Each of the 5 dimensions were rated on 5-point scales, where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. The number in brackets is the number of participants.

Subjective Assessment of Mental Performance

	Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
	Group1 (22)		Group3 (6)		Group1 (21)		Group3 (6)		Group1 (19)		Group3 (6)		Group1 (16)		Group3 (6)		Group1 (9)		Group3 (4)		Group1 (9)		Group3 (4)	
	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd
1) trouble making decisions	0.40	1.00	0.10	0.23	0.27	0.38	0.12	0.29	0.23	0.37	0.07	0.12	0.23	0.51	0.05	0.12	0.22	0.37	0.18	0.22	0.29	0.35	0.07	0.15
2) trouble with memory	0.27	0.54	0.10	0.23	0.32	0.51	0.19	0.35	0.31	0.68	0.05	0.12	.31	0.68	0.10	0.17	0.29	0.56	0.32	0.41	.03	.33	0.04	0.07
3) trouble with simple tasks	0.27	0.42	0.07	0.18	0.34	0.50	0.12	0.29	0.32	0.62	0.05	0.12	0.29	0.66	0.05	0.12	0.29	0.57	0.14	0.20	0.25	0.35	0.00	0.00
4) trouble with concentration and attention	0.41	.63	0.12	0.23	0.39	0.49	0.10	0.17	0.44	0.64	0.05	0.07	0.41	0.78	0.17	0.26	0.57	0.83	0.29	0.35	.53	0.51	0.29	0.29
5) general apathy	0.22	0.41	0.02	0.06	0.23	0.38	0.05	0.07	0.21	0.36	0.07	0.08	0.21	0.39	0.10	0.23	0.46	0.56	0.39	0.49	0.35	0.46	0.18	0.36

Fatigue

Commanding Officer and Chief Engineer Assessments of Crew Fatigue and Workload.

Table B-9:
Weekly means for assessments of crew fatigue and workload from commanding officers (CO) and chief engineers (CE). CO assessments are for the entire crew. CE assessments are for engineering crew only. Assessments were made using a 17-point scale, where: 1=low, 9=medium and 17=high. Also shown are high and low weeks for fatigue and workload and percent differences between high and low. n=number of CO's and CE's making assessments.

CO Assessment (Entire Crew)

	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		High week	Rating	Low week	Rating	Percent Difference
	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean		Mean		Mean	
Fatigue	4	6.29	4	7.14	4	7.40	4	7.89	4	9.57	4	11.07	6	11.07	2	7.14	24.5
Workload	4	10.34	4	8.63	4	8.46	4	8.29	4	9.43	4	9.57	6	9.57	4	8.29	8.0

CE Assessment (Engineering Crew)

	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		High week	Rating	Low week	Rating	Percent Difference
	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean		Mean		Mean	
Fatigue	3	8.57	3	11.25	3	12.00	3	9.62	3	10.86	3	11.00	3	12.00	4	9.62	14.9
Workload	3	8.86	3	11.15	3	12.35	3	9.77	3	11.29	3	11.57	3	12.35	4	9.77	16.2

Socio-Psychological Factors

Pre-watch Mood

Table B-10:
Weekly means and standard deviations (± sd) for 6 dimensions of pre-watch mood for Groups 1 and 3. Each dimension of mood was rated on a 17-point scale, where: 1=low; 9=medium; and 17=high. The number in brackets is the number of participants.

Pre-watch Mood

	Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
	Group1 (21)		Group3 (6)		Group1 (21)		Group3 (6)		Group1 (18)		Group3 (6)		Group1 (16)		Group3 (6)		Group1 (9)		Group3 (4)		Group1 (9)		Group3 (3)	
	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd
Alertness	11.22	2.33	12.47	3.61	11.04	2.70	11.96	3.45	11.41	2.88	11.16	2.93	10.53	2.61	10.78	3.56	9.85	2.80	11.07	4.02	10.29	3.23	11.31	4.63
Cheerfulness†	10.95	3.58	11.82	3.45	10.40	3.58	11.09	3.39	10.15	4.05	10.55	3.51	9.25	3.86	10.05	3.62	7.37	3.04	10.32	4.69	7.47	2.93	9.06	7.19
Calmness†	12.21	3.09	12.39	3.44	12.39	3.23	11.62	3.04	11.64	3.43	11.97	2.84	10.72	3.74	11.20	3.02	9.71	4.41	12.38	3.20	9.19	3.49	11.48	5.23
Irritability†	5.32	2.92	5.83	3.23	4.89	2.76	4.73	3.12	4.43	2.76	4.03	2.67	5.19	3.33	4.15	2.90	7.41	4.50	4.48	2.81	7.52	4.67	5.43	3.84
Confidence	12.14	2.51	13.43	3.23	12.46	2.49	13.53	2.85	12.41	2.73	13.44	2.91	11.70	2.80	12.96	3.27	10.73	2.78	12.01	3.43	11.09	3.81	12.36	4.07
Withdrawal†	4.71	2.72	3.64	2.23	4.54	2.93	2.74	1.77	4.07	2.51	2.72	1.22	4.69	3.35	3.02	1.40	6.61	3.30	4.37	2.80	7.03	3.14	5.57	4.01

† Trend for Group1 only

Socio-Psychological Factors

Post-watch Mood

Table B-11:
Weekly means and standard deviations (± sd) for 6 dimensions of post-watch mood for Groups 1 and 3. Each dimension was rated on a 17-point scale, where: 1=low; 9=medium; and 17=high. The number in brackets is the number of participants.

Post-watch Mood

	Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
	Group1 (22)		Group3 (6)		Group1 (20)		Group3 (6)		Group1 (17)		Group3 (6)		Group1 (16)		Group3 (6)		Group1 (9)		Group3 (4)		Group1 (9)		Group3 (3)	
	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd
Alertness	10.16	2.47	11.97	2.90	10.89	2.27	12.10	2.86	10.85	2.65	11.35	4.00	10.52	2.82	10.71	3.94	10.36	2.78	11.44	4.35	10.30	2.53	10.41	5.75
Cheerfulness	9.65	3.51	10.92	3.78	9.70	3.23	10.34	3.36	9.52	3.59	10.69	4.19	9.02	3.69	9.56	3.97	7.82	2.63	10.72	5.08	6.50	3.19	8.96	7.18
Calmness	11.44	3.20	12.16	3.56	10.97	3.31	11.71	2.95	11.16	3.77	11.59	3.62	9.93	4.06	11.41	3.44	9.42	3.61	12.44	3.17	9.24	4.18	11.24	5.36
Irritability†	5.68	3.26	5.08	3.54	5.26	3.22	4.55	3.06	5.06	2.65	4.27	2.81	6.28	4.11	3.77	2.81	7.79	4.61	3.53	2.78	8.76	4.94	5.17	3.62
Confidence	12.17	2.62	13.98	3.11	12.06	2.50	13.55	2.95	11.68	2.81	13.55	2.82	11.24	2.86	13.25	2.98	10.44	2.80	12.61	2.99	10.20	2.88	12.73	3.72
Withdrawal*	4.76	2.82	3.29	2.15	4.57	3.05	2.83	1.79	4.52	2.74	2.81	1.29	4.64	3.30	3.03	1.37	6.51	3.00	3.86	2.37	7.96	4.15	5.84	4.33

* Significant effects for Group1 only
† Trend for Group1 only

Socio-Psychological Factors

Group dynamics, morale and response to stress

Table B-12:
Means and standard deviations (± sd) at days 1, 7, 14, 28 and 42 for group dynamics and morale (3 factors), and response to stressor experienced during CCG operations (5 factors) Data are for Groups 1 and 3 combined. All factors are rated on a 5-point scale, where: 0=none; 1=a little; 2=some; 3=quite a bit; 4=very much. Number of participants is designated by n.

Group dynamics, morale and response to stress

	Day 1			Day 7			Day 14			Day 28			Day 42		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**	**n**	**Mean**	**± sd**	**n**	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Group Dynamics															
Morale/cohesion**	23	1.66	1.49	5	3.00	0.75	22	2.47	0.99	20	2.12	1.34	14	1.75	1.42
Professional morale*	23	2.26	1.89	5	4.00	0.00	22	3.50	0.91	20	3.05	1.61	14	2.57	1.99
Leadership skills*	23	1.75	1.58	5	3.40	0.43	22	2.55	1.16	20	1.86	1.26	14	1.55	1.44
Stressors															
Logistical support / Personnel Resources**	23	0.72	0.95	5	1.00	0.71	22	1.48	0.89	19	1.25	0.95	13	1.27	1.16
Work Scheduling	22	0.95	1.31	5	1.70	0.97	22	1.52	1.27	19	1.21	1.15	12	1.5	1.73
Family Separation**	23	0.85	0.83	5	1.83	1.03	23	0.71	1.05	20	1.36	1.09	14	1.3	1.19
Personal Control/Well-being	23	0.44	0.63	5	0.50	0.41	23	0.89	0.71	20	0.94	0.88	14	0.79	0.92
Work Relationships	23	0.41	0.67	5	0.70	0.45	22	0.86	0.76	19	0.92	0.85	12	0.79	0.96

* Significant effects
** Trends

Additional Measures

Frequency of Daily Medication

Table B-13:
Weekly percentage of crew using daily medication. Daily medication use was a yes (Y) or no (N) response. The number in brackets is the number of participants.

Frequency of Daily Medication

Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
Group1 (21)		Group3 (6)		Group1 (20)		Group3 (6)		Group1 (18)		Group3 (6)		Group1 (16)		Group3 (6)		Group1 (9)		Group3 (4)		Group1 (9)		Group3 (3)	
% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N	% Y	% N
27.3	72.7	50.0	50.0	28.6	71.4	66.7	33.3	31.6	68.4	50.0	50.0	25.0	75.0	33.3	66.7	22.2	77.8	25.0	75.0	33.3	66.7	25.0	75.0

Additional Measures

Pre-Watch Symptoms

Table B-14:
Weekly means and standard deviations (± sd) for 10 pre-watch symptoms. Symptoms were rated on a 5-point scale, where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. The number in brackets is the number of participants.

Pre-Watch Symptoms

	Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
	Group1 (22)		Group3 (6)		Group1 (21)		Group3 (6)		Group1 (19)		Group3 (6)		Group1 (16)		Group3 (6)		Group1 (9)		Group3 (4)		Group1 (9)		Group3 (3)	
	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd
discomfort	0.47	0.55	0.16	0.18	0.47	0.58	0.19	0.22	0.47	0.57	0.15	0.16	0.29	0.34	0.19	0.28	0.40	0.42	0.14	0.20	0.33	0.35	0.11	0.14
stomach awareness	0.42	0.58	0.12	0.18	0.48	0.58	0.33	0.47	0.32	0.53	0.36	0.35	0.30	0.48	0.24	0.32	0.33	0.57	0.18	0.27	0.24	0.37	0.21	0.34
headache	0.16	0.27	0.27	0.31	0.24	0.33	0.31	0.39	0.41	0.57	0.40	0.28	0.25	0.30	0.31	0.39	0.33	0.29	0.36	0.36	0.26	0.27	0.36	0.34
yawning	0.34	0.43	0.18	0.17	0.50	0.62	0.31	0.34	0.50	0.51	0.45	0.51	0.74	0.76	0.27	0.30	0.56	0.48	0.64	0.53	0.44	0.40	0.25	0.29
physical fatigue	0.84	0.76	0.56	0.66	0.86	0.79	0.59	0.60	0.75	0.83	0.57	0.77	0.96	0.83	0.45	0.55	1.33	1.09	1.14	0.93	1.02	0.71	0.86	0.91
mental fatigue	0.66	0.79	0.56	0.32	0.75	0.73	0.48	0.52	0.58	0.64	0.43	0.37	0.78	0.73	0.36	0.42	0.87	0.83	0.97	0.76	0.83	0.81	0.61	0.63
drowsy	0.69	0.93	0.53	0.39	0.70	0.79	0.64	0.38	0.61	0.59	0.52	0.39	0.72	0.62	0.38	0.36	0.86	0.66	0.75	0.59	0.73	0.73	0.32	0.37
apathy††	0.45	1.09	0.17	0.27	0.44	0.62	0.22	0.25	0.43	0.68	0.29	0.25	0.57	0.64	0.24	0.27	0.75	0.85	0.90	0.76	0.58	0.84	0.57	0.70
tension/ anxiety	0.42	0.85	0.44	0.35	0.44	0.87	0.24	0.17	0.44	0.76	0.21	0.33	0.37	0.66	0.12	0.19	0.59	0.89	0.61	0.44	0.38	0.64	0.39	0.46
dizziness	0.07	0.13	0.05	0.12	0.10	0.26	0.07	0.12	0.09	0.24	0.10	0.17	0.08	0.20	0.10	0.15	0.16	0.32	0.04	0.07	0.09	0.17	0.00	0.00

†† Trend for Group 3 only

Additional Measures

Post-Watch Symptoms

Table B-15:
Weekly means and standard deviations (± sd) for 10 post-watch symptoms. Symptoms were rated on a 5-point scale, where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. The number in brackets is the number of participants.

Post-Watch Symptoms

	Week 1				Week 2				Week 3				Week 4				Week 5				Week 6			
	Group1 (22)		Group3 (6)		Group1 (21)		Group3 (6)		Group1 (19)		Group3 (6)		Group1 (16)		Group3 (6)		Group1 (9)		Group3 (4)		Group1 (9)		Group3 (3)	
	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd	Mean	± sd
discomfort	0.47	0.75	0.22	0.40	0.44	0.48	0.07	0.12	0.47	0.71	0.12	0.14	0.38	0.43	0.26	0.28	0.33	0.40	0.14	0.20	0.45	0.44	0.18	0.27
stomach awareness	0.65	0.93	0.12	0.19	0.45	0.56	0.17	0.28	0.35	0.52	0.24	0.28	0.40	0.59	0.29	0.27	0.33	0.51	0.25	0.41	0.33	0.51	0.32	0.29
headache	0.21	0.31	0.29	0.41	0.27	0.39	0.22	0.22	0.40	0.62	0.29	0.36	0.34	0.44	0.26	0.37	0.36	0.42	0.32	0.38	0.40	0.43	0.40	0.36
yawning	0.72	0.63	0.20	0.26	0.67	0.54	0.22	0.15	0.68	0.57	0.33	0.42	0.79	0.68	0.26	0.28	0.68	0.61	0.32	0.38	0.52	0.36	0.32	0.29
physical fatigue	1.23	0.80	0.59	0.41	1.07	0.74	0.79	0.78	1.07	0.90	0.74	1.02	1.31	1.01	0.57	0.68	1.51	1.06	1.18	1.13	1.20	0.64	0.93	0.79
mental fatigue	1.23	0.74	0.56	0.35	1.01	0.65	0.74	0.67	0.99	0.78	0.59	0.74	1.04	0.78	0.48	0.58	1.06	0.93	0.86	0.84	0.98	0.77	0.75	0.65
drowsy	1.03	0.85	0.54	0.39	0.79	0.64	0.62	0.50	0.80	0.68	0.48	0.33	0.86	0.79	0.36	0.35	0.94	0.78	0.54	0.47	0.74	0.65	0.57	0.61
apathy	0.42	0.56	0.18	0.32	0.52	0.47	0.17	0.23	0.47	0.55	0.24	0.20	0.55	0.64	0.33	0.28	0.73	0.87	0.75	0.80	0.52	0.69	0.54	0.68
tension/anxiety	0.48	0.70	0.30	0.33	0.46	0.65	0.34	0.30	0.41	0.69	0.31	0.51	0.53	0.83	0.17	0.23	0.63	1.00	0.50	0.50	0.33	0.65	0.43	0.50
dizziness	0.21	0.45	0.10	0.17	0.11	0.23	0.07	0.08	0.12	0.23	0.07	0.08	0.11	0.22	0.05	0.07	0.10	0.29	0.00	0.00	0.09	0.17	0.00	0.00

APPENDIX C

Differences between 4&8 and 12&12 Watches

Cognitive

Performance

Table C-1:
Means and standard deviations (± sd) on the Delta tests for Groups 1 and 3 combined. STM = short term memory; GR = grammatical reasoning; MP = mathematical processing; CRT = choice reaction time; SPC = successive pattern comparison; SP= spatial processing. Data are presented in terms of: response time (RT measured in seconds); accuracy (% correct); and rejections (number of times participants were rejected on tests because criterion performance levels were not attained). Number of participants is designated by n.

Cognitive Performance: Delta

		4&8			12&12		
		n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
STM	RT	9	0.78	0.11	15	0.82	0.21
	% Correct	9	97.64	1.06	15	96.70	1.75
GR	RT	n/a	n/a	n/a	11	3.34	0.73
	% Correct	n/a	n/a	n/a	11	91.33	8.06
MP	RT*	9	1.87	0.41	15	2.41	0.42
	% Correct	9	96.23	2.42	15	96.26	1.87
SP	RT	9	1.87	0.35	15	2.06	0.25
	% Correct	9	96.61	1.88	15	96.69	2.17
SPC	RT	9	1.07	0.19	15	1.18	0.22
	% Correct**	9	93.60	1.84	15	90.93	3.75
CRT	RT	9	0.56	0.07	15	0.61	0.09
	% Correct	9	98.89	0.83	15	98.68	1.26

* Significant effects
** Trend
n/a no data available

Cognitive

Performance

Table C-2:
Mean failure rates as expressed by percentage of failures (percentage of times participants were rejected on tests because criterion performance levels were not attained) on the Delta tests for Groups 1 and 3 combined. T=trials, F=failures. Number of participants is designated by n.

Cognitive Performance: Delta Failures

	n	Total #T	Total #F	%F
4&8	7	301	6	1.99
12&12	7	284	19	6.69
Total	14	585	25	4.27

Cognitive Assessment

Situational Awareness

Table C-3:
Means and standards deviations (± sd) for situational awareness for Groups 1 and 3 combined. Data were scored on a 7-point scale, where: 1 = low; 4 = medium; and 7 = high situational awareness. The number of participants is designated by n.

Situational Awareness

	4&8			12&12		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Pre-Watch	10	5.18	1.01	17	5.05	1.10
Post-Watch	10	5.53	1.05	16	4.96	1.28

Subjective Workload

Table C-4:
Means and standard deviations (± sd) for subjective workload for Groups 1 and 3 combined. Data for each of the 7 dimensions of workload, as well as for overall and relative workload, were scored on separate 17-point scales where: 1=low; 9=meduim and 17=high workload. The number of participants is designated by n.

Subjective Workload

	4&8			12&12		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Mental	10	9.37	1.40	17	10.50	2.49
Visual**	10	9.63	1.67	17	11.24	2.29
Physical	10	7.97	3.27	17	9.24	2.24
Temporal	10	9.01	1.73	17	9.21	2.91
Performance	10	10.55	2.29	17	11.89	1.94
Effort	10	9.28	1.90	17	10.02	2.79
Frustration	10	7.32	3.04	17	5.30	3.22
Overall	10	9.46	1.70	16	10.01	2.26
Relative	10	9.39	1.44	16	9.40	2.13

** Trend

Sleep

Sleep Duration and Quality (Activity Log and PAM/2)

Table C-5:
Means and standard deviations (± sd) for sleep duration (minutes) and quality for Groups 1 and 3 combined. Sleep quality was rated on a 7-point scale, where: 1=poor; 4=fair; and 7=excellent. Number of participants is designated by n.

Sleep Duration (Activity Log and PAM/2)

4&8			12&12		
n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
8	390.97	51.64	13	399.59	47.17

Sleep Quality (Activity Log)

4&8			12&12		
n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
8	4.86	0.81	13	4.49	0.97

NightCap

Table C-6:
Means and standard deviations (± sd) on the NightCap for Groups 1 and 3 combined for: sleep efficiency (sleep duration (min.)/sleep period (min.), where sleep period= sleep duration plus time awake (min.)); sleep latency (min.); and sleep duration (min.). Number of participants is designated by n.

NightCap

	4&8			12&12		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Sleep Duration*	6	313.33	49.38	3	458.67	55.54
Sleep Latency**	6	15.02	9.63	3	31.08	11.68
Sleep Efficiency	6	90.68	4.36	3	86.51	4.08

*`Significant
**`Trend

Fatigue

Subjective Assessment of Task and Mental Performance

Table C-7:
The first two tables indicate percentage of participants from Groups 1 and 3 combined who experienced degraded task and mental performance (NO/YES). Task and mental performance were each rated on 5-point scales, where: 0=not at all; 1=a little, 2=somewhat, 3=quite a bit, and 4=extremely. The third table shows means and standard deviations (± sd) on 5 items for participants reporting degraded mental performance. The number of participants in all cases is designated by n.

Subjective Assessment of Task Performance

	4&8		12&12	
	n	**Percent**	**n**	**Percent**
No	0	0.0	6	35.3
Yes*	10	100.0	11	64.7

* Significant

Subjective Assessment of Mental Performance

	4&8		12&12	
	n	**Percent**	**n**	**Percent**
No	1	10.0	7	41.2
Yes**	9	90.0	10	58.8

** Trend

Self Assessment of Mental Performance

	4&8			12&12		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
1) trouble making decisions	10	0.23	0.34	17	0.24	0.36
2) trouble with memory	10	0.29	0.43	17	0.30	0.47
3) trouble with simple tasks	10	0.22	0.36	17	0.31	0.52
4) trouble with concentration and attention	10	0.46	0.56	17	0.35	0.52
5) general apathy	10	0.25	0.34	17	0.24	0.33

Socio-Psychological Factors

Pre-watch Mood

Table C-8:
Means and standard deviations (± sd) for 6 dimensions of pre-watch mood for Groups 1 and 3 combined. Each was rated on a 17-point scale, where: 1=low; 9=medium; and 17=high. Number of participants is designated by n.

Pre-Watch Mood

	4&8			12&12		
	n	Mean	± sd	n	Mean	± sd
Alertness	10	10.70	3.04	17	11.06	2.54
Cheerfulness**	10	8.46	3.16	17	10.87	3.64
Calmness	10	10.57	3.77	17	12.23	2.65
Irritability	10	5.89	2.73	17	4.36	2.80
Confidence	10	11.64	2.95	17	12.75	2.38
Withdrawal**	10	5.74	2.51	17	3.86	2.79

** Trend

Post-watch Mood

Table C-9:
Means and standard deviations (± sd) for 6 dimensions of post-watch mood for Groups 1 and 3 combined. Each was rated on a 17-point scale, where: 1=low; 9=medium; and 17=high. Number of participants is designated by n.

Post-Watch Mood

	4&8			12&12		
	n	Mean	± sd	n	Mean	± sd
Alertness	10	10.89	2.57	16	10.88	2.77
Cheerfulness**	10	8.15	2.58	16	10.38	3.68
Calmness	10	10.35	3.62	16	11.16	3.08
Irritability**	10	6.68	2.48	16	4.66	3.35
Confidence**	10	11.07	2.82	16	12.76	2.32
Withdrawal	10	5.76	2.63	16	4.05	3.06

** Trend

Socio-Psychological Factors

Group dynamics, morale and response to stress

Table C-10:
Means and standard deviations (± sd) for group dynamics and morale (3 factors), and response to stressor experienced during CCG operations (5 factors) for Groups 1 and 3 combined. All factors are rated on a 5-point scale, where: 0=none; 1=a little; 2=some; 3=quite a bit; 4=very much. Number of participants is designated by n.

Group dynamics, morale and response to stress

	4&8			12&12		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Group Dynamics & Morale						
Morale/Cohesion**	10	1.80	0.76	14	2.41	0.91
Professional Morale*	10	2.50	0.94	14	3.33	0.60
Leadership Skills*	10	1.67	0.60	14	2.49	1.00
Stressors						
Logistical Support / Personnel Resources	10	1.07	0.58	14	1.19	0.95
Work Scheduling	10	1.37	0.95	14	1.19	1.13
Family Separation**	10	1.08	0.50	14	1.52	0.67
Personal Control / Well Being	10	0.61	0.36	14	0.84	0.71
Work Relationships	10	0.64	0.31	14	0.83	0.66

* Significant
** Trend

Additional Measures

Frequency of Daily Medication

Table C-11:
Percentage of crew using daily medication from Groups 1 and 3 combined (NO/YES). Number of participants is designated by n.

Frequency of Daily Medication				
	4&8		12&12	
	n	Percent	n	Percent
No	4	40.0	9	52.9
Yes	6	60.0	8	47.1

Symptoms

Table C-12:
Means and standard deviations (± sd) for 10 pre-watch symptoms for Groups 1 and 3 combined. Symptoms were rated on a 5-point scale, where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. Number of participants is designated by n.

Pre- Watch Symptoms						
	4&8			12&12		
	n	Mean	± sd	n	Mean	± sd
discomfort	10	0.34	0.34	17	0.46	0.47
stomach awareness	10	0.27	0.53	17	0.47	0.42
headache	10	0.29	0.30	17	0.33	0.32
yawning	10	0.43	0.43	17	0.61	0.61
physical fatigue	10	1.07	0.87	17	0.69	0.61
mental fatigue	10	0.74	0.64	17	0.68	0.60
drowsiness	10	0.71	0.65	17	0.67	0.59
apathy	10	0.52	0.61	17	0.47	0.57
tension/ anxiety	10	0.43	0.77	17	0.38	0.58
dizziness	10	0.12	0.28	17	0.07	0.10

Additional Measures

Symptoms

Table C-13:
Means and standard deviations (± sd) for 10 post-watch symptoms for Groups 1 and 3 combined. Symptoms were rated on a 5-point scale, where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. Number of participants is designated by n.

Post-Watch Symptoms

	4&8			12&12		
	n	Mean	± sd	n	Mean	± sd
discomfort	10	0.38	0.39	17	0.43	0.46
stomach awareness	10	0.27	0.49	17	0.47	0.37
headache	10	0.32	0.31	17	0.33	0.41
yawning	10	0.61	0.46	17	0.61	0.52
physical fatigue	10	1.31	0.85	17	0.92	0.74
mental fatigue	10	0.97	0.68	17	0.95	0.69
drowsiness	10	0.74	0.62	17	0.78	0.57
apathy	10	0.53	0.62	17	0.48	0.46
tension/ anxiety	10	0.46	0.81	17	0.43	0.53
dizziness	10	0.12	0.26	17	0.08	0.08

APPENDIX D

Differences between Day and Night Watches

Cognitive Assessment

Performance

Table D-1:
Means and standard deviations (± sd) on the Delta tests for Groups 1 and 3 combined. STM = short term memory; GR = grammatical reasoning; MP = mathematical processing; CRT = choice reaction time; SPC = successive pattern comparison; SP= spatial processing. Data are presented in terms of: response time (RT measured in seconds); accuracy (% correct); and rejections (number of times participants were rejected on tests because criterion performance levels were not attained). Number of participants is designated by n.

Cognitive Performance: Delta

		Day			Night		
		n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
STM	RT	14	0.85	0.20	10	0.75	0.10
	% Correct	14	97.03	1.81	10	97.09	1.27
GR	RT	6	3.54	0.51	5	3.09	0.93
	% Correct	6	91.17	5.87	5	91.53	10.92
MP	RT**	14	2.34	0.55	10	2.01	0.30
	% Correct	14	96.26	1.96	10	96.23	2.26
SP	RT	14	2.05	0.26	10	1.90	0.35
	% Correct	14	96.77	2.23	10	96.51	1.80
SPC	RT	14	1.15	0.26	10	1.14	0.13
	% Correct	14	92.26	3.58	10	91.47	3.23
CRT	RT	14	0.60	0.09	10	0.58	0.07
	% Correct	14	98.53	1.23	10	99.10	0.85

**Trend

Cognitive

Performance

Table D-2:
Mean failure rates as expressed by percentage of failures (percentage of times participants were rejected on tests because criterion performance levels were not attained) on the Delta tests for Groups 1 and 3 combined. T=trials, F=failures. Number of participants is designated by n.

Cognitive Performance: Delta Failures

	n	Total #T	Total #F	%F
Day	7	277	11	3.97
Night	7	308	14	4.55
Total	14	585	25	4.27

Cognitive Assessment

Situational Awareness

Table D-3:
Means and standard deviations (± sd) for Groups 1 and 3 combined. Data were scored on a 7-point scale, where: 1 = low; 4 = medium; and 7 = high situational awareness. The number of participants is designated by n.

Situational Awareness						
	Day			Night		
	n	Mean	± sd	n	Mean	± sd
Pre-Watch	17	5.22	0.94	10	4.88	1.23
Post-Watch	17	5.34	1.02	9	4.87	1.52

Subjective Workload

Table D-4:
Means and standard deviations (± sd) for subjective workload for Groups 1 and 3 combined. Data for each of the 7 dimensions of workload, as well as for overall and relative workload, were scored on separate 17-point scales where: 1=low; 9=meduim and 17=high workload. The number of participants is designated by n.

Subjective Workload						
	Day			Night		
	n	Mean	± sd	n	Mean	± sd
Mental	17	10.11	2.54	10	10.03	1.55
Visual**	17	10.63	2.28	10	10.67	2.15
Physical	17	8.34	3.14	10	9.50	1.48
Temporal	17	8.98	2.86	10	9.39	1.85
Performance**	17	11.69	1.90	10	10.88	2.52
Effort	17	9.68	2.96	10	9.85	1.50
Frustration**	17	5.31	2.77	10	7.31	3.75
Overall	17	9.89	2.38	9	9.62	1.31
Relative	17	9.43	2.04	9	9.34	1.59

** Trend

Sleep

Sleep Duration and Quality (Activity Log and PAM/2)

Table D-5:
Means and standard deviations (± sd) for sleep duration (minutes) and quality for Groups 1 and 3 combined. Sleep quality was rated on a 7-point scale, where: 1=poor; 4=fair; and 7=excellent. Number of participants is designated by n.

Sleep Duration (Activity Log and PAM/2)					
Day			Night		
n	Mean	± sd	n	Mean	± sd
13	402.76	41.61	8	385.80	57.98

Sleep Quality (Activity Log)					
Day			Night		
n	Mean	± sd	n	Mean	± sd
13	4.72	0.69	8	4.48	1.23

NightCap

Table D-6:
Means and standard deviations (± sd) on the NightCap for Groups 1 and 3 combined for: sleep efficiency (sleep duration (min.)/sleep period (min.), where sleep period=sleep duration plus time awake (min.)); sleep latency (min.); and sleep duration (min.). Number of participants is designated by n.

NightCap						
	Day			Night		
	n	Mean	± sd	n	Mean	± sd
Sleep Duration**	6	394.50	84.03	3	296.33	64.89
Sleep Latency	6	23.05	12.74	3	15.03	12.51
Sleep Efficiency	6	88.64	4.82	3	90.58	4.42

** Trend

Fatigue

Subjective Assessment of Task and Mental Performance

Table D-7:
The first two tables indicate percentage of participants from Groups 1 and 3 combined who experienced degraded task and mental performance (NO/YES). Task and mental performance were each rated on 5-point scales, where: 0=not at all; 1=a little, 2=somewhat, 3=quite a bit, and 4=extremely. The third table shows means and standard deviations (±sd) on 5 items for participants reporting degraded mental performance. The number of participants in all cases is designated by n.

Subjective Assessment of Task Performance

	Day		Night	
	n	Percent	n	Percent
No	4	23.5	2	20.0
Yes	13	76.5	8	80.0

Subjective Assessment of Mental Performance

	Day		Night	
	n	Percent	n	Percent
No	5	29.4	3	30.0
Yes	12	70.6	7	70.0

Self Assessment of Mental Performance

	Day			Night		
	n	Mean	± sd	n	Mean	± sd
1) trouble making decisions	17	0.20	0.29	10	0.29	0.44
2) trouble with memory	17	0.26	0.38	10	0.34	0.56
3) trouble with simple tasks	17	0.25	0.42	10	0.34	0.54
4) trouble with concentration and attention	17	0.31	0.39	10	0.52	0.71
5) general apathy	17	0.23	0.32	10	0.26	0.36

Socio-Psychological Factors

Pre-watch Mood

Table D-8:
Means and standard deviations (±sd) for 6 dimensions of pre-watch mood for Groups 1 and 3 combined. Each was rated on a 17-point scale, where: 1=low; 9=medium; and 17=high. Number of participants is designated by n.

Pre-Watch Mood

	Day			Night		
	n	Mean	± sd	n	Mean	± sd
Alertness	17	11.14	2.51	10	10.57	3.06
Cheerfulness**	17	10.83	3.20	10	8.54	3.97
Calmness	17	12.25	2.81	10	10.53	3.54
Irritability	17	4.47	2.30	10	5.71	3.53
Confidence	17	12.66	2.54	10	11.79	2.77
Withdrawal	17	4.22	2.80	10	5.14	2.83

** Trend

Post-watch Mood

Table D-9:
Means and standard deviations (±sd) for 6 dimensions of post-watch mood for Groups 1 and 3 combined. Each was rated on a 17-point scale, where: 1=low; 9=medium; and 17=high. Number of participants is designated by n.

Post-Watch Mood

	Day			Night		
	n	Mean	± sd	n	Mean	± sd
Alertness	17	11.33	2.49	9	10.04	2.88
Cheerfulness*	17	10.56	3.18	9	7.56	3.15
Calmness*	17	11.75	2.89	9	9.16	3.37
Irritability	17	4.90	2.82	9	6.45	3.68
Confidence*	17	12.83	2.33	9	10.74	2.69
Withdrawal	17	4.47	3.04	9	5.16	2.96

* Significant

Socio-Psychological Factors

Group dynamics, morale and response to stress

Table D-10:
Means and standard deviations (±sd) for group dynamics and morale (3 factors), and response to stressor experienced during CCG operations (5 factors) for Groups 1 and 3 combined. All factors are rated on a 5-point scale, where: 0=none; 1=a little; 2=some; 3=quite a bit; 4=very much. Number of participants is designated by n.

Group dynamics, morale and response to stress

	Day			Night		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Group Dynamics & Morale						
Morale/Cohesion	13	2.36	0.95	11	1.92	0.79
Professional Morale	13	3.07	0.96	11	2.88	0.73
Leadership Skills**	13	2.45	0.99	11	1.79	0.77
Stressors						
Logistical Support / Personnel Resources	13	0.94	0.60	11	1.38	0.97
Work Scheduling	13	1.04	0.81	11	1.54	1.24
Family Separation	13	1.40	0.60	11	1.26	0.69
Personal Control / Well Being	13	0.60	0.48	11	0.92	0.69
Work Relationships	13	0.73	0.60	11	0.77	0.49

** Trend

Additional Measures

Frequency of Daily Medication

Table D-11:
Percentage of crew using daily medication from Groups 1 and 3 combined (NO/YES). Number of participants is designated by n.

Frequency of Daily Medication				
	Day		Night	
	n	Percent	n	Percent
No	7	41.2	6	60.0
Yes	10	58.8	4	40.0

Additional Measures

Pre-watch Symptoms

Table D-12:
Means and standard deviations (±sd) for 10 pre-watch symptoms for Groups 1 and 3 combined. Symptoms were rated on a 5-point scale, where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. Number of participants is designated by n.

Pre- Watch Symptoms

	Day			Night		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
discomfort	17	0.44	0.43	10	0.36	0.43
stomach awareness	17	0.39	0.40	10	0.40	0.58
headache	17	0.30	0.32	10	0.33	0.31
yawning	17	0.58	0.60	10	0.49	0.47
physical fatigue	17	0.72	0.50	10	1.03	1.01
mental fatigue	17	0.68	0.50	10	0.74	0.78
drowsiness	17	0.64	0.56	10	0.77	0.68
apathy	17	0.41	0.49	10	0.62	0.71
tension/ anxiety	17	0.27	0.39	10	0.61	0.92
dizziness	17	0.07	0.10	10	0.13	0.28

Additional Measures

Post-watch Symptoms

Table D-13:
Means and standard deviations (±sd) for 10 post-watch symptoms for Groups 1 and 3 combined. Symptoms were rated on a 5-point scale, where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. Number of participants designated by n.

Post-Watch Symptoms

	Day			Night		
	n	Mean	± sd	n	Mean	± sd
discomfort	17	0.42	0.45	10	0.40	0.42
stomach awareness	17	0.36	0.32	10	0.45	0.57
headache	17	0.29	0.39	10	0.39	0.35
yawning	17	0.53	0.47	10	0.75	0.52
physical fatigue	17	0.92	0.64	10	1.31	0.98
mental fatigue	17	0.97	0.66	10	0.94	0.73
drowsiness	17	0.67	0.54	10	0.91	0.63
apathy	17	0.39	0.44	10	0.68	0.61
tension/ anxiety	17	0.32	0.39	10	0.64	0.91
dizziness	17	0.06	0.07	10	0.16	0.25

APPENDIX E

The Impact of 8 versus 15 Days of Icebreaking

Cognitive Assessment

Performance

Table E-1:
Means and standard deviations (±sd) on the Delta tests for Groups 1 and 3 combined. STM = short term memory; GR = grammatical reasoning; MP = mathematical processing; CRT = choice reaction time; SPC = successive pattern comparison; SP= spatial processing. Data are presented in terms of: response time (RT measured in seconds); accuracy (% correct); and rejections (number of times participants were rejected on tests because criterion performance levels were not attained). Number of participants is designed by n.

Cognitive Performance: Delta

		8 Days			15 Days		
		n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
STM	RT	11	0.88	0.17	11	0.79	0.12
	% Correct	11	97.36	2.59	11	97.17	1.52
GR	RT	5	3.65	0.67	4	3.35	0.49
	% Correct	5	88.54	9.47	4	87.33	9.54
MP	RT	11	2.25	0.44	11	2.27	0.59
	% Correct	11	96.62	1.89	11	95.59	2.14
SP	RT	11	2.09	0.30	11	2.14	0.36
	% Correct	11	95.63	4.93	11	93.82	4.26
SPC	RT	11	1.18	0.25	11	1.08	0.22
	% Correct	11	93.15	5.16	11	91.77	3.59
CRT	RT	11	0.64	0.13	11	0.59	0.08
	% Correct	11	99.15	1.30	11	98.67	1.15

Cognitive

Performance

Table E-2:
Mean failure rates as expressed by percentage of failures (percentage of times participants were rejected on tests because criterion performance levels were not attained) on the Delta tests for Groups 1 and 3 combined. T=trials, F=failures. Number of participants is designated by n.

Cognitive Performance: Delta Failures

	n	Total #T	Total #F	%F
8 Days	4	251	14	5.58
15 Days	10	334	11	3.29
Total	14	585	25	4.27

Cognitive Assessment

Situational Awareness

Table E-3:
Means and standard deviations (±sd) for Groups 1 and 3 combined. Data were scored on a 7-point scale, where: 1 = low; 4 = medium; and 7 = high situational awareness. The number of participants is designated by n.

Situational Awareness

	8 Days			15 Days		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Pre-Watch	9	5.32	1.47	14	5.03	0.70
Post-Watch	9	5.24	1.71	14	5.16	0.92

Subjective Workload

Table E-4:
Means and standard deviations (±sd) for subjective workload for Groups 1 and 3 combined. Data for each of the 7 dimensions of workload, as well as for overall and relative workload, were scored on separate 17-point scales where: 1=low; 9=meduim and 17=high workload. Number of participants is designated by n.

Subjective Workload

	8 Days			15 Days		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Mental	9	10.10	1.25	14	9.17	2.67
Visual	9	10.66	1.19	14	10.45	2.24
Physical	9	9.04	1.93	14	7.56	2.90
Temporal	9	7.18	3.23	14	8.10	2.66
Performance	9	12.24	1.60	14	10.87	2.52
Effort**	9	9.71	1.77	14	8.27	2.29
Frustration	9	3.76	3.46	14	5.52	3.17
Overall	9	9.93	1.42	14	8.70	2.21
Relative**	9	10.16	1.64	14	8.63	2.01

** Trend

Sleep

Sleep Duration and Quality (Activity Log and PAM/2)

Table E-5:
Means and standard deviations (±sd) for sleep duration (minutes) and quality for Groups 1 and 3 combined. Sleep quality was rated on a 7-point scale, where: 1=poor; 4=fair; and 7=excellent. Number of participants is designated by n.

Sleep Duration (Activity Log and PAM/2)					
8 Days			15 Days		
n	Mean	± sd	n	Mean	± sd
9	415.43	57.88	12	403.60	41.85

Sleep Quality (Activity Log)					
8 Days			15 Days		
n	Mean	± sd	n	Mean	± sd
7	4.39	1.55	12	4.61	0.83

NightCap

Table E-6:
Means and standard deviations (±sd) on the NightCap for Groups 1 and 3 combined for: sleep efficiency (sleep duration (min.)/sleep period (min.), where sleep period=sleep duration plus time awake (min.)); sleep latency (min.); and sleep duration (min.). Number of participants is designated by n.

NightCap						
	8 Days			15 Days		
	n	Mean	± sd	n	Mean	± sd
Sleep Duration	2	323.00	25.46	6	392.00	94.71
Sleep Latency	2	25.84	1.65	6	14.83	10.76
Sleep Efficiency	2	88.55	5.00	6	93.23	2.99

Fatigue

Subjective Assessment of Task and Mental Performance

Table E-7:
The first two tables indicate percentage of participants from Groups 1 and 3 combined who experienced degraded task and mental performance (NO/YES). Task and mental performance were each rated on 5-point scales, where: 0=not at all; 1=a little, 2=somewhat, 3=quite a bit, and 4=extremely. The third table shows means and standard deviations (±sd) on 5 items for participants reporting degraded mental performance. The number of participants in all cases is designated by n.

Subjective Assessment of Task Performance

	8 Days		15 Days	
	n	Percent	n	Percent
No	3	33.3	3	23.1
Yes	6	66.7	10	76.9

Subjective Assessment of Mental Performance

	8 Days		15 Days	
	n	Percent	n	Percent
No	6	66.7	3	21.4
Yes*	3	33.3	11	78.6

* Significant

Self Assessment of Mental Performance

	8 Days			15 Days		
	n	Mean	± sd	n	Mean	± sd
1) trouble making decisions	9	0.25	0.56	14	0.25	0.36
2) trouble with memory	9	0.31	0.72	14	0.35	0.54
3) trouble with simple tasks	9	0.33	0.83	14	0.36	0.54
4) trouble with concentration and attention	9	0.38	0.91	14	0.47	0.58
5) general apathy	9	0.18	0.45	14	0.25	0.41

Fatigue

Commanding Officer and Chief Engineer Assessment

Table E-8:
Means and standard deviations (±sd) for assessments of crew workload and fatigue from commanding officers (CO) and chief engineers (CE). CO assessments are for the entire crew. CE assessments are for engineering crew only. Assessments were made using a 17-point scale, where: 1=low, 9=medium and 17=high. Number of participants is designated by n.

CO Assessment (Entire Crew)

	8 Days		15 Days		
	n	Mean	n	Mean	Percent Difference
Workload	4	9.95	4	9.80	0.94
Fatigue	4	8.00	4	9.20	7.53

Fatigue: CE Assessment (Engineering Crew)

	8 Days		15 Days		
	n	Mean	n	Mean	Percent Difference
Workload	3	8.63	3	11.60	18.56
Fatigue	3	8.69	3	10.67	12.38

Socio-Psychological Factors

Pre-watch Mood

Table E-9:
Means and standard deviations (±sd) for 6 dimensions of pre-watch mood for Groups 1 and 3 combined. Each was rated on a 17-point scale, where: 1=low; 9=medium; and 17=high. Number of participants is designated by n.

Pre-Watch Mood						
	8 Days			15 Days		
	n	Mean	± sd	n	Mean	± sd
Alertness	9	11.88	3.14	14	10.63	2.50
Cheerfulness	9	9.91	4.17	14	10.11	3.10
Calmness	9	12.12	3.38	14	11.33	3.45
Irritability	9	4.18	3.39	14	5.46	2.45
Confidence	9	12.51	2.37	14	12.27	2.82
Withdrawal**	9	2.75	1.96	14	4.58	2.62

** Trend

Post-watch Mood

Table E-10:
Means and standard deviations (±sd) for 6 dimensions of post-watch mood for Groups 1 and 3 combined. Each was rated on a 17-point scale, where: 1=low; 9=medium; and 17=high. Number of participants is designated by n.

Post-Watch Mood						
	8 Days			15 Days		
	n	Mean	± sd	n	Mean	± sd
Alertness	9	11.24	3.57	14	10.32	1.95
Cheerfulness	9	9.72	3.94	14	9.83	3.06
Calmness	9	11.42	4.09	14	11.09	3.25
Irritability	9	3.99	3.80	14	5.69	2.44
Confidence	9	12.65	2.71	14	12.07	2.77
Withdrawal**	9	2.52	2.02	14	4.60	2.69

** Trend

Socio-Psychological Factors

Group dynamics, morale and response to stress

Table E-11:
Means and standard deviations (±sd) for group dynamics and morale (3 factors), and response to stressors experienced during CCG operations (5 factors) for Groups 1 and 3 combined. All factors are rated on a 5-point scale, where: 0=none; 1=a little; 2=some; 3=quite a bit; 4=very much. Number of participants is designated by n.

Group dynamics, morale and response to stress

	8 Days			15 Days		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Group Dynamics & Morale						
Morale/Cohesion	6	2.64	1.12	13	2.42	1.01
Professional Morale	6	4.00	0.00	13	3.46	1.13
Leadership Skills	6	2.89	1.31	13	2.26	0.96
Stressors						
Logistical Support / Personnel Resources	6	1.42	1.20	13	1.25	0.79
Work Scheduling**	6	1.92	1.02	13	1.04	1.01
Family Separation	6	1.78	0.94	13	1.71	1.19
Personal Control / Well Being	6	0.90	1.04	13	0.97	0.83
Work Relationships	6	0.83	0.52	13	1.00	0.74

** Trend

Additional Measures

Frequency of Daily Medication

Table E-12:
Percentage of crew using daily medication from Group 1 and 3 combined (NO/YES). Number of participants is designated by n.

Frequency of Daily Medication				
	8 Days		15 Days	
	n	Percent	n	Percent
No	5	55.6	7	50.0
Yes	4	44.4	7	50.0

Additional Measures

Pre-watch Symptoms

Table E-13:
Means and standard deviations (±sd) for 10 pre-watch symptoms for Groups 1 and 3 combined. Symptoms were rated on a 5-point scale where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. Number of participants is designed by n.

Pre- Watch Symptoms						
	8 Days			15 Days		
	n	Mean	± sd	n	Mean	± sd
discomfort	9	0.32	0.43	14	0.40	0.44
stomach awareness	9	0.28	0.46	14	0.42	0.53
headache	9	0.24	0.25	14	0.36	0.37
yawning	9	0.50	0.57	14	0.48	0.52
physical fatigue	9	0.86	0.64	14	0.83	0.83
mental fatigue	9	0.70	0.76	14	0.59	0.59
drowsiness	9	0.71	0.60	14	0.65	0.52
apathy	9	0.40	0.70	14	0.41	0.45
tension/ anxiety	9	0.35	0.71	14	0.39	0.67
dizziness	9	0.07	0.13	14	0.11	0.25

Additional Measures

Post-watch Symptoms

Table E-14:
Means and standard deviations (±sd) for 10 post-watch symptoms for Groups 1 and 3 combined. Symptoms were rated on a 5-point scale where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. Number of participants is designated by n.

Post-Watch Symptoms

	8 Days			15 Days		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
discomfort	9	0.36	0.53	14	0.33	0.49
stomach awareness	9	0.45	0.67	14	0.39	0.56
headache	9	0.35	0.46	14	0.34	0.41
yawning	9	0.77	0.78	14	0.64	0.47
physical fatigue	9	1.29	0.91	14	1.07	0.85
mental fatigue	9	1.10	0.85	14	0.95	0.59
drowsiness	9	0.99	1.03	14	0.67	0.41
apathy	9	0.52	0.75	14	0.40	0.42
tension/ anxiety	9	0.47	0.89	14	0.43	0.68
dizziness	9	0.10	0.14	14	0.12	0.25

APPENDIX F

The Impact of Icebreaking Early as Opposed to Late in the Crewing Period

Cognitive Assessment

Performance

Table F-1:
Means and standard deviations (±sd) on the Delta tests for Groups 1 and 3 combined. STM = short term memory; GR = grammatical reasoning; MP = mathematical processing; CRT = choice reaction time; SPC = successive pattern comparison; SP= spatial processing. Data are presented in terms of: response time (RT measured in seconds); accuracy (% correct); and rejections (number of times participants were rejected on tests because criterion performance levels were not attained). Number of participants is designed by n.

Cognitive Performance: Delta

		Early			Late		
		n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
STM	RT	10	0.79	0.13	12	0.87	0.16
	% Correct	10	96.62	2.24	12	97.80	1.85
GR	RT	4	3.35	0.49	5	3.65	0.67
	% Correct	4	87.33	9.54	5	88.54	9.47
MP	RT	10	2.35	0.55	12	2.19	0.49
	% Correct	10	95.37	2.28	12	96.72	1.67
SP	RT	10	2.23	0.27	12	2.02	0.35
	% Correct*	10	92.16	5.26	12	96.87	2.59
SPC	RT*	10	1.02	0.19	12	1.23	0.23
	% Correct	10	92.33	4.71	12	92.57	4.32
CRT	RT	10	0.64	0.13	12	0.60	0.08
	% Correct	10	98.90	1.31	12	98.92	1.20

* Significant

Cognitive

Performance

Table F-2:
Mean failure rates as expressed by percentage of failures (percentage of times participants were rejected on tests because criterion performance levels were not attained) on the Delta tests for Groups 1 and 3 combined. T=trials, F=failures. Number of participants is designated by n.

Cognitive Performance: Delta Failures

	n	Total #T	Total #F	%F
Early	5	246	6	2.44
Late	9	339	19	5.60
Total	14	585	25	4.27

Cognitive Assessment

Situational Awareness

Table F-3:
Means and standard deviations (±sd) for situational awareness for Groups 1 and 3 combined. Data were scored on a 7-point scale where: 1 = low; 4 = medium; and 7 = high situational awareness. The number of participants is designated by n.

Situational Awareness

	Early			Late		
	n	Mean	± sd	n	Mean	± sd
Pre-Watch*	12	5.56	0.96	11	4.69	0.98
Post-Watch	12	5.47	1.10	11	4.89	1.38

* Significant

Subjective Workload

Table F-4:
Means and standard deviations (± sd) for subjective workload for Groups 1 and 3 combined. Data for each of the 7 dimensions of workload as well as for overall and relative workload, were scored on separate 17-point scales where: 1=low; 9=meduim and 17=high workload. The number of participants is designated by n.

Subjective Workload

	Early			Late		
	n	Mean	± sd	n	Mean	± sd
Mental	12	9.21	2.34	11	9.89	2.16
Visual	12	10.85	1.64	11	10.18	2.11
Physical	12	8.55	2.23	11	7.70	3.04
Temporal	12	6.99	3.27	11	8.55	2.19
Performance	12	12.08	1.98	11	10.68	2.42
Effort	12	8.93	2.22	11	8.73	2.25
Frustration*	12	3.34	1.95	11	6.47	3.82
Overall	12	9.16	2.14	11	9.20	1.95
Relative	12	9.00	2.26	11	9.47	1.73

* Significant

Sleep

Sleep Duration and Quality (Activity Log and PAM/2)

Table F-5:
Means and standard deviations (± sd) for sleep duration (minutes) and quality for Groups 1 and 3 combined. Sleep quality was rated on a 7-point scale where: 1=poor; 4=fair; and 7=excellent. The number of participants is designated by n.

Sleep Duration (Activity Log and PAM/2)					
Early			Late		
n	Mean	± sd	n	Mean	± sd
10	423.05	57.59	11	395.60	36.05

Sleep Quality (Activity Log)					
Early			Late		
n	Mean	± sd	n	Mean	± sd
10	4.70	1.05	9	4.34	1.21

NightCap

Table F-6:
Means and standard deviations (± sd) on the NightCap for Groups 1 and 3 combined for: sleep efficiency (sleep duration (min.)/sleep period (min.) where sleep period=sleep duration plus time awake (min.)); sleep latency (min.); and sleep duration (min.). The number of participants is designated by n.

NightCap						
	Early			Late		
	n	Mean	± sd	n	Mean	± sd
Sleep Duration	4	410.50	105.00	4	339.00	55.82
Sleep Latency	4	21.04	7.32	4	14.13	12.99
Sleep Efficiency	4	90.09	3.46	4	94.02	3.45

Fatigue

Subjective Assessment of Task and Mental Performance

Table F-7:
The first 2 tables indicate percentage of participants from Groups 1 and 3 combined who experienced degraded task and mental performance (NO, YES). Task and mental performance were each rated on 5-point scales, where: 0=not at all; 1=a little, 2=somewhat, 3=quite a bit, and 4=extremely. The third table shows means and standard deviations (± sd) on 5 items for participants reporting degraded mental performance. The number of participants in all cases is designated by n.

Subjective Assessment of Task Performance

	Early		Late	
	n	**Percent**	**n**	**Percent**
No	4	33.3	2	20.0
Yes	8	66.7	8	80.0

Subjective Assessment of Mental Performance

	Early		Late	
	n	**Percent**	**n**	**Percent**
No	6	50.0	3	27.3
Yes	6	50.0	8	72.7

Self Assessment of Mental Performance

	Early			Late		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
1) trouble making decisions	12	0.14	0.27	11	0.36	0.56
2) trouble with memory	12	0.23	0.48	11	0.44	0.71
3) trouble with simple tasks	12	0.25	0.51	11	0.45	0.78
4) trouble with concentration and attention	12	0.25	0.47	11	0.63	0.88
5) general apathy	12	0.14	0.34	11	0.32	0.49

Fatigue

Commanding Officer and Chief Engineer Assessment

Table F-8:
Means and standard deviations (± sd) for assessments of crew workload and fatigue from commanding officers (CO) and chief engineers (CE). CO assessments are for the entire crew. CE assessments are for engineering crew only. Assessments were made using a 17-point scale, where: 1=low, 9=medium and 17=high. The number of participants is designated by n.

CO Assessment (Entire Crew)

	Early		Late		
	n	Mean	n	Mean	Percent Difference
Workload	4	9.81	4	9.94	0.94
Fatigue	4	7.63	4	9.57	7.53

CE Assessment (Engineering Crew)

	Early		Late		
	n	Mean	n	Mean	Percent Difference
Workload	3	10.63	3	9.12	18.56
Fatigue	3	10.88	3	8.59	12.38

Socio-Psychological Factors

Pre-watch Mood

Table F-9:
Means and standard deviations (± sd) for 6 dimensions of pre-watch mood for Groups 1 and 3 combined. Each was rated on a 17-point scale where: 1=low; 9=medium; and 17=high. The number of participants is designated by n.

Pre-Watch Mood

	Early			Late		
	n	Mean	± sd	n	Mean	± sd
Alertness**	12	12.09	2.61	11	10.06	2.65
Cheerfulness**	12	11.14	3.43	11	8.82	3.22
Calmness*	12	13.12	2.65	11	10.02	3.43
Irritability*	12	3.78	2.15	11	6.24	3.05
Confidence**	12	13.32	2.27	11	11.31	2.63
Withdrawal*	12	2.54	1.40	11	5.31	2.69

* Significant
** Trend

Post-watch Mood

Table F-10:
Means and standard deviations (± sd) for 6 dimensions of post-watch mood for Groups 1 and 3 combined. Each was rated on a 17-point scale where: 1=low; 9=medium; and 17=high. The number of participants is designated by n.

Post-Watch Mood

	Early			Late		
	n	Mean	± sd	n	Mean	± sd
Alertness**	12	11.68	2.62	11	9.59	2.35
Cheerfulness*	12	11.18	3.02	11	8.26	3.11
Calmness*	12	12.72	2.87	11	9.58	3.53
Irritability*	12	3.58	2.07	11	6.61	3.31
Confidence*	12	13.72	2.12	11	10.74	2.46
Withdrawal*	12	2.53	1.56	11	5.15	2.90

* Significant
** Trend

Socio-Psychological Factors

Group dynamics, morale and response to stress

Table F-11:
Means and standard deviations (± sd) for group dynamics and morale (3 factors), and response to stressors experienced during CCG operations (5 factors) for Groups 1 and 3 combined. All factors are rated on a 5-point scale where: 0=none; 1=a little; 2=some; 3=quite a bit; 4=very much. The number of participants is designated by n.

Group dynamics, morale and response to stress

	Early			Late		
	n	**Mean**	**± sd**	**n**	**Mean**	**± sd**
Group Dynamics & Morale						
Morale/Cohesion	10	2.57	0.85	9	2.39	1.22
Professional Morale	10	3.70	0.48	9	3.56	1.33
Leadership Skills**	10	2.90	0.90	9	1.96	1.11
Stressors						
Logistical Support / Personnel Resources*	10	0.85	0.54	9	1.81	0.99
Work Scheduling	10	1.00	1.03	9	1.67	1.06
Family Separation	10	1.67	1.02	9	1.80	1.22
Personal Control / Well Being*	10	0.46	0.35	9	1.49	0.97
Work Relationships*	10	0.60	0.46	9	1.33	0.66

* Significant
** Trend

Additional Measures

Frequency of Daily Medication

Table F-12:
Percentage of crew using daily medication from Groups 1 and 3 combined. Daily medication use was a Yes or No response. The number of participants is designated by n.

Frequency of Daily Medication				
	Early		Late	
	n	Percent	n	Percent
No	5	41.7	7	63.6
Yes	7	58.3	4	36.4

Additional Measures

Pre-watch Symptoms

Table F-13:
Means and standard deviations for 10 pre-watch symptoms for Groups 1 and 3 combined. Symptoms were rated on a 5-point scale where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. The number of participants is designated by n.

Pre- Watch Symptoms						
	Early			Late		
	n	Mean	± sd	n	Mean	± sd
discomfort	12	0.34	0.45	11	0.40	0.43
stomach awareness	12	0.27	0.34	11	0.47	0.62
headache	12	0.27	0.32	11	0.36	0.33
yawning**	12	0.30	0.50	11	0.70	0.49
physical fatigue*	12	0.53	0.55	11	1.18	0.81
mental fatigue**	12	0.40	0.47	11	0.89	0.74
drowsiness**	12	0.49	0.39	11	0.87	0.63
apathy**	12	0.22	0.37	11	0.62	0.64
tension/ anxiety**	12	0.14	0.19	11	0.63	0.89
dizziness	12	0.06	0.10	11	0.14	0.29

* Significant
** Trend

Additional Measures

Post-watch Symptoms

Table F-14:
Means and standard deviations (± sd) for 10 post-watch symptoms for Groups 1 and 3 combined. Symptoms were rated on a 5-point scale where: 0=not at all; 1=a little; 2=somewhat; 3=quite a bit; 4=extremely. The number of participants designated by n.

Post-Watch Symptoms

4	Early			Late		
	n	Mean	± sd	n	Mean	± sd
discomfort	12	0.23	0.49	11	0.47	0.49
stomach awareness	12	0.29	0.45	11	0.55	0.71
headache	12	0.27	0.40	11	0.42	0.45
yawning	12	0.51	0.55	11	0.88	0.61
physical fatigue*	12	0.74	0.60	11	1.61	0.90
mental fatigue**	12	0.76	0.55	11	1.28	0.74
drowsiness**	12	0.56	0.45	11	1.05	0.87
apathy**	12	0.27	0.36	11	0.65	0.68
tension/ anxiety*	12	0.14	0.18	11	0.78	0.98
dizziness	12	0.07	0.07	11	0.17	0.29

APPENDIX G

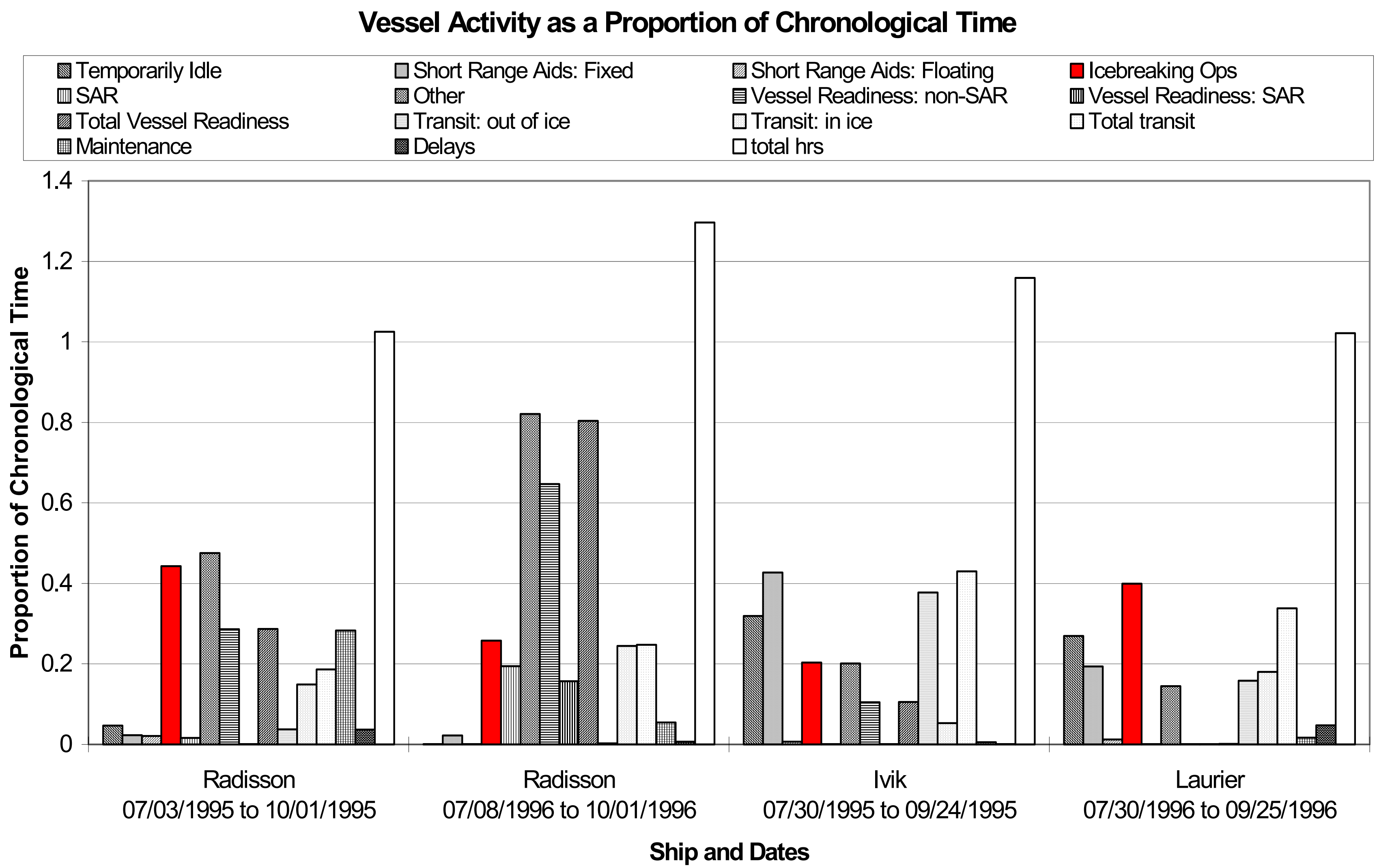
Body Temperature Shifts for Night Workers (Adaptation or Re-entrainment)

Table G-1:
Times of highest (Max Temp) and lowest (Min Temp) recorded body temperature for participants 109 and 110, watch 3 Radisson 4&8.

Participant #	Day	Max Temp	Time of High	Min Temp	Time of Low
109	7	37.5	0:00	37.4	4:00
109	12	37	0:00	36.1	12:00
109	13	37.3	12:00	36.1	4:00
109	18	37	0:00	36.1	12:00
109	26	36.8	0:00	36	4:00
109	27	36.7	0:00	36.4	4:00
109	28	37.5	16:00	36.1	0:00
109	30	36.1	0:00	36	12:00
109	31	34.4	0:00	34.4	0:00
109	32	35.4	0:00	35	12:00
109	33	35.5	0:00	35.5	0:00
110	6	36.4	16:00	35.6	4:00
110	7	35.8	0:00	35.6	4:00
110	8	36.2	16:00	35.4	4:00
110	9	36.4	12:00	35.7	0:00
110	10	36.1	12:00	35.4	4:00
110	11	36.2	12:00	35.4	4:00
110	12	36.2	12:00	35.7	0:00
110	27	36.1	4:00	36.1	4:00
110	28	37.7	12:00	36.6	20:00
110	29	37.1	20:00	35.8	4:00
110	30	36.6	12:00	36.6	12:00
110	31	37	16:00	35.8	4:00
110	32	37.2	20:00	36.3	4:00
110	33	37.2	20:00	36.6	12:00
110	34	36.8	0:00	36.5	4:00
110	35	37.5	12:00	36.4	20:00
110	36	36.8	12:00	35.6	4:00
110	37	36.8	0:00	36.2	4:00
110	38	36.8	0:00	36.3	4:00
110	39	37	0:00	36.7	12:00
110	40	36.6	16:00	36.2	0:00
110	41	37	8:00	36.6	0:00

APPENDIX H

FAIS Analysis of Vessel Activity



Vessel Activity as a Proportion of Chronological Time
Temporarily Idle
Short Range Aids: Fixed
Short Range Aids: Floating
Icebreaking Ops
SAR
Other
Vessel Readiness: non-SAR
Vessel Readiness: SAR
Total Vessel Readiness
Transit: out of ice
Transit: in ice
Total transit
Maintenance
Delays
total hrs
Proportion of Chronological Time
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Radisson
07/03/1995 to 10/01/1995
Radisson
07/08/1996 to 10/01/1996
Ivik
07/30/1995 to 09/24/1995
Laurier
07/30/1996 to 09/25/1996
Ship and Dates

APPENDIX I

Task Analysis of Bridge and Engine Room Watchkeepers

ICEBREAKER TASK ANALYSIS: BRIDGE AND ENGINEERING WATCHKEEPERS

1 Introduction

Task demands influence arousal and fatigue. Accepted models of arousal and performance suggest that optimal levels of arousal or internal activation exist for different types of tasks. Monotonous routine tasks such as looking for infrequent, unexpected targets and monitoring displays, as is the case with many watchkeeping activities, rapidly lead to lower arousal levels. Low arousal levels are characterized by lapses in attention, increased reaction time, diminished memory and failure to complete procedures. When combined with low arousal levels and fatigue, monotonous routine tasks pose a particular concern to performance and safety. Performance feedback can help mitigate these effects, but the overall potential for catastrophic failure rises significantly when arousal levels dip below a critical level. The relationship between task demands and arousal levels emphasizes the importance of identifying task characteristics by means of a task analysis to determine which tasks are most prone to fatigue effects.

Tasks that are more sensitive to sleep loss include addition, auditory and visual vigilance, reaction time, memory and tracking tests. Performance may also be affected by environmental or operational situations such as physical exercise, noise, temperature, drugs and air quality. Aspects of performance affected by fatigue which are of particular concern to marine operations are long duration tasks that are externally paced, complex, and require high levels of attention, memory and vigilance. Newly learned tasks and responses to novel situations as well as situations requiring insightful solutions are also particularly sensitive to fatigue.

Personnel aboard Coast Guard vessels deployed to the Arctic are in a unique situation with respect to the issue of fatigue and watch scheduling. When on Arctic Operations, Coast Guard employees are aboard the vessel for the duration of the on-duty work cycle (i.e., 28 or 42 or more days) without being exposed to the potential stress and disruptions/distractions of a daily commute. Quite often shore based shift workers spend a significant amount of time preparing for work, traveling to work, and preparing meals. For personnel aboard Coast Guard vessels the time normally spent commuting to work and preparing meals is virtually eliminated while on the ship. In addition, when the vessel departs its home port, the persons assigned to the ship (particularly Ships Officers) have the opportunity to adapt their circadian rhythms for the duration of the on-duty work cycle. This may have advantages over the typical shore based shift worker who may go home after every shift and/or work a certain shift for up to 7 days before having to switch to another shift.

1.1 Task Analysis

1.1.1 Objective

A task analysis of the bridge and engine room watchkeepers' activities was performed to identify critical activities that may be particularly sensitive to fatigue.

1.1.2 Methodology

The specific approach to task analysis utilized in this investigation involved both observational techniques and interviews with CCG representatives including helmsmen, navigators, engineers, oilers, and commanding officers. Incumbents provided information about specific tasks and underlying component processes. These descriptions were later verified by the commanding officers.

1.2 Modes of Operation

Depending upon the mode of operation (e.g., steaming, SAR, icebreaking) and the individual's position (i.e., engine room, navigator or helmsman), specific task requirements and workload demands vary considerably. Not only are the tasks performed by the navigator, helmsman, and engineers very different (although the navigator and helmsman do perform some similar tasks), but the workload in each location changes independently as a function of the ship's mode of operation. For example, during normal steaming the workload on the bridge is relatively low, especially if the auto pilot is steering the ship. While at the same time, the workload in the engine room is relatively high because the mechanical systems of the ship are operating.

The primary modes of operation are:

- Steaming: this includes steaming through ice free waters and waters containing small amounts of ice;
- Maneuvering through ice: this includes steaming through waters occupied by ice but still containing leads to follow through the ice. In this case, ice may still be hit and broken by the ship but this occurs relatively infrequently;
- Icebreaking: this involves frequent contact with, and breaking of ice;
- Ice Escort: this involves escorting another vessel through ice laden waters and occurs in conjunction with maneuvering through ice and ice breaking;
- Temporarily Idle: the ship may be at anchor, stopped and drifting, waiting for daylight, etc.; and
- Search and Rescue.

The most intense modes of operation with the highest workload and stress levels occur during ice escorts and during SAR events.

1.3 Responsibilities of Bridge Watchkeepers

Although some tasks performed by the helmsman differ greatly from those performed by the navigator, they do share some tasks. Tasks shared by the helmsman and navigator on the bridge include communicating with the engine room, coordinating deployment of the FRC, communicating using other devices (UHF, VHF, telephone, fax), maintaining aids to navigation, and searching for leads.

1.3.1 Communicating with the Engine Room

Radio and telephone communication between the bridge and engine room is essential to ensure that the vessel is prepared for upcoming mechanical requirements. Engine room crew must be informed of sailing plans and upcoming power requirements to ensure these can be met. The bridge watchkeepers communicate this information to the engine room when significant power or course changes are required and receive verbal confirmation that this information has been received and implemented. Improper communication may result in an inability to meet the requirements of the bridge and has the potential to affect overall vessel performance and safety. Levels of communication between the bridge and engine room increase while maneuvering through ice, icebreaking and during ice escort and SAR.

1.3.2 Coordinating deployment of the FRC

When the decision is made to deploy the FRC, the bridge watchkeepers coordinate the crew to prepare the boat for travel. The bridge watchkeepers ensure that the ship is optimally situated for FRC deployment relative to wind and waves, that safety procedures are being followed and that the FRC crew is aware of the travel or search plans. The FRC is often deployed during SAR events, which increases the need for safety, efficiency, communication and proper preparation for a potentially long trip in adverse weather conditions and high sea states. The bridge watchkeepers may be required to divide their attention between navigation, helm activities and FRC deployment. During FRC operation, continuous radio and radar contact between the two vessels is maintained.

1.3.3 Other Communications (UHF, VHF, telephone, fax)

Communication with the RCC, CCG headquarters, marine vessel traffic services and other nearby ships is vital to coordinate activities and to maintain efficient vessel operation. The bridge watchkeepers are responsible for maintaining communication through radio (UHF/VHF), autotel telephone and fax. During icebreaking operations and in the role of 'on-scene commander' during SAR, these activities intensify. All communication is entered in the ship's log. Failure to maintain proper communication decreases efficiency and has the potential to create a marine hazard.

1.3.4 Maintaining of Aids to Navigation

Bridge watchkeepers may be tasked to maintain aids to navigation. Aids to navigation must be maintained to ensure safe passage of waterways by sea going vessels. This involves activities such as repairing damaged equipment and painting the navigational aids so they are highly visible. Although maintenance of aids to navigation is important, other events such as ice escorts and SAR take precedence.

1.3.5 Searching for leads

A lead is a channel of open water between ice floes. Following leads has several potential advantages including reducing wear and tear on the ship and improving transit time. However, following leads may increase transit time if the leads take the ship too far off course. To maximize the ship's efficiency and effectiveness, the captain establishes parameters for the transit of the vessel. To arrive at these parameters, the captain considers such factors as: ship's speed; time requirements; depth of water; weather; visibility; time of day; ice conditions; wear and tear on the ship; current; cost; fuel; and safety.

When searching for leads, the bridge watchkeepers visually (and with radar if possible) scan the water from the bow to the horizon, searching for the best route. The best route depends on parameters established by the captain and the ice conditions. Visual scanning is accomplished using both the naked eye and binoculars.

Searching for leads becomes more critical during ice escorts and when the ship must reach a destination quickly. Searching for leads becomes more difficult in fog, rain, snow and at night. In these conditions there is a danger of following a blind lead, forcing the ship to back track or perhaps causing the ship to become trapped in the ice.

1.4 Helmsman

Although the navigator and helmsman share some duties, the helmsman, is also responsible for collecting meteorological information and conning or steering the ship.

1.4.1 Collecting of Meteorological Information

The helmsman collect meteorological information including wind speed, visibility, air temperature, sea temperature and sea conditions which is entered into the ship's log. This information is reported to the officer of the watch who submits the information to Environment Canada for broadcast weather reports, and prepares the crew and ship for upcoming weather conditions. This task is performed regularly every two hours. However, the frequency may increase in adverse weather conditions or decrease during a SAR event. Weather checks are carried out in conjunction with other tasks such as performing rounds of the ship.

1.4.2 Conning or Steering the Ship

The primary responsibility of the helmsman is to steer the ship. During normal steaming in ice free water, the ship's wheel is ordinarily "in auto" meaning the auto pilot is steering the vessel, thus reducing the helmsman's workload in terms of physically steering the vessel. In this case, the helmsman is primarily acting as a lookout. Typically, acting as a lookout involves maintaining a constant visual watch for anomalous objects in the water, including objects which may have a particularly low profile which prevents them from showing up on radar. In doing so, the lookout brings all potentially significant objects to the attention of the navigator or other bridge personnel. Depending upon the particular mode of vessel operation, the objects of interest will vary. For example, during vessel transit, objects of interest may include geographical markers and navigational aids (e.g., beacons and lights), as well as other vessels and floating debris such as pieces of ice, icebergs, and any other objects with the potential to affect vessel transit and safety.

When the helmsman is required to steer the ship, "the wheel is put in hand", which means that the helmsman is guiding the vessel as opposed to the auto pilot steering the vessel. Steering the ship requires the helmsman to control the direction of the vessel by changing the angle of the rudder with a steering wheel or jog-stick. Visual feedback about rudder angle is provided by a device attached to the deckhead (ceiling) or by a rudder angle indicator on the helm. The rudder angle indicator provides feedback regarding desired versus actual rudder angle which is necessary because there is a lag between the time the rudder angle is set and the time the rudder reaches that angle. The lag is affected by the number of steering pumps that are operating. The ship has two pumps to change the rudder angle; when one pump is on, the rudder and ship respond more slowly than when two pumps are operating. The helmsman must know how many pumps are on when he is steering so he can anticipate the vessel's response.

When the wheel is in hand the helmsman is also responsible for maintaining the ships heading. This is done by visual monitoring of the gyro repeater compass situated in front of him and by setting the rudder angle so that the ship follows the desired course. It is important to note that the gyro repeater compass in front of the helmsman has a manually set counter to record the heading. Thus, it is not necessary for the helmsman to remember the heading as long as the counter is set properly.

If the ship's heading must be changed, the navigator verbally relays the new heading to the helmsman in the form of a three digit number (e.g., 322). The helmsman then verbally confirms the new heading by repeating the instructions given to him. If no correction is made by the navigator, the helmsman proceeds to steer to the new heading. Once the new heading has been reached, the helmsman relays this to the navigator in the form of the original three digit number, and the navigator confirms the new heading by repeating this information.

When the wheel is in hand the helmsman also monitors wind speed and direction as these factors may have a significant effect on the performance of the ship and movement of ice. Therefore, monitoring wind speed and direction is particularly important when maneuvering through ice and icebreaking.

1.5 Navigator

The navigator is responsible for: the overall general safety of the vessel; initiating or completing vessel transit; bearing determination and verification of position; plotting the ship’s course; maintaining the ship's log; coordinating deployment of the helicopter; and communicating with other bridge and engine room personnel. The navigator also monitors ship's alarms and other electronic monitoring systems, such as the fire detection system, the propulsion system, and the watertight door indicators.

1.5.1 Initiating or Completing Vessel Transit

The navigator acts as the coordinator of all ship's personnel in preparing for vessel transit as well as ship docking, dropping and setting anchor. The following tasks are performed each time the ship leaves anchor or pulls away from the dock, prior to getting underway.

- Call vessel traffic services with departure time
- Coordinate and sequence appropriate charts and lay course
- Telegraph check to engines
- Check steering and synchronize gyro repeater
- Check all navigational equipment
- Turn on radar/ align heading marker
- Coordinate flying of proper signal flags (if appropriate)
- Check communications (functioning of equipment)
- Ensure all personnel are informed
- Secure deck equipment
- Moor and set lines from dock/anchor position
- Determine and report position relative to other vessels

Variations of these tasks are also performed upon completion of transit. These tasks are performed to ensure that the ship transits safely and in concurrence with marine regulations.

1.5.2 Determining Bearing and Verifying Position

The navigator is responsible for determining and verifying the ship's position by assessing and comparing navigational information from different sources of equipment. The ship's position may be established through data which are provided by GPS (Global Positioning System), LORAN, radar, depth sounder, and compass readings as well as by celestial and terrestrial fixes. GPS, LORAN and radar provide direct sources of information on the ship's position. Sounding checks provide information on the amount of water beneath the keel. In conjunction with marine charts, this information can assist in establishing vessel position. To coordinate navigational information and verify position, readings from various instruments are compared to each other and to navigational charts. This task establishes and verifies position, and checks instrument calibration and function. Errors in position or bearing result in navigational errors which increase the risk of running aground, collision and reduced ice breaking or SAR efficiency.

The primary source of navigational information may vary depending on tides, geography of the area and weather. For example, compass readings using the gyro repeater compass, cannot be taken in poor visibility, and the navigator will rely more heavily on the GPS or LORAN. This task is performed frequently during steaming, and less frequently when anchored.

Navigators report that bearing determination and verification of position are more difficult with high sea states, fatigue, motion sickness, adverse weather conditions and reduced visibility. Precise visual readings from the gyro repeater compass may not be possible under high motion. Using the radar may increase motion sickness symptoms as the navigator is exposed less to the visual horizon when concentrating on the radar display, especially with the secondary radar which requires placing the face in a rubber mask to eliminate external glare on the screen. During high sea states, less reliance is placed on the radar as small targets are likely to be missed in the sea clutter.

1.5.3 Plotting Course

The ship's course must be regularly charted to establish and record the present position and planned route of the vessel. The ship's route is plotted by hand on standard paper marine charts, using traditional equipment (e.g., parallel rulers, dividers, pencil, eraser). While in transit, the navigator updates the plot every 20 to 30 minutes or when a course change is made. This task is highly critical. Information feedback related to course plotting is provided by navigational equipment and aids, and geographical markers. Errors in course plotting may result in navigational error affecting ship safety and efficiency.

Plotting an accurate course becomes increasingly complex during SAR incidents when attempting to maintain accurate search patterns. This may become further complicated by assuming the role of 'on scene commander', when the search patterns of several vessels may need to be established and coordinated simultaneously. During such times, it also may be necessary for the navigator to issue position and situation reports to the Rescue Coordination Centre (RCC).

Navigators report increased difficulty plotting course with high sea states, poor weather or visibility, fatigue and motion sickness. Equipment readings are more difficult to discern and less reliable. In high sea states the charts are constantly shifting on the chart table. The navigator may also have difficulty in performing mental calculations and spatial orientation tasks with symptoms of fatigue and motion sickness.

1.5.4 Maintaining the Ship's Log

The navigator is required to maintain a detailed and accurate log details of navigation and activities of the ship and crew. The log is updated every 30 minutes or if there is a significant event, such as a course change or identification of a navigational marker. In addition to the navigational or deck log, a radio and an incident log are also kept.

Maintaining the ship's log involves compiling appropriate course and event information, tabulating these data in a proper format, and integrating information into final report form.

The logs are handwritten. During a period of high activity (such as SAR, poor weather or high sea states), there is more use of abbreviated entries. Under these conditions, course changes and ship activities may be taped on an audio recorder, with details being entered into the log at a later opportunity. Failing to maintain an accurate log increases the potential for subsequent navigational error which places the vessel at risk, and results in having inaccurate records for future reference.

1.5.5 Coordinating Deployment of the Helicopter

When a decision is made to deploy the helicopter, the navigator coordinates the crew to prepare it for travel. The navigator ensures that the ship is optimally situated relative to wind and waves for helicopter deployment, that safety procedures are being followed and that the helicopter crew is aware of the travel or search plans. The helicopter is often deployed during SAR events, which increases the need for safety, efficiency, good communication and proper preparation for a potentially long trip in adverse weather conditions. The bridge watchkeepers may be required to divide their attention between navigation, helm activities and helicopter deployment. During helicopter operation, continuous radio contact between the vessel and the helicopter is maintained.

1.6 Responsibilities of Engine Room Watchkeepers

There are two watchkeepers on duty in the engine room at all times, an Engineer and an Oiler. The tasks performed by the watchkeepers in the engine room differ significantly from those performed by either of the watchkeepers on the bridge. However, each of the watchkeepers in the engine room perform similar duties, but the Engineer is ultimately responsible for the safe and efficient operation of the engine room.

1.6.1 Watchkeeping Rounds and Repairing Equipment

The watchkeepers in the engine room are responsible for maintenance and operation of the ship's engines and mechanical apparatus (e.g., pumps, motors, pipes, hoses). To accomplish this, the watchkeepers in the engine room typically perform rounds once an hour. While one watchkeeper performs the rounds, the other remains in the control room, to monitor such things as gauges, alarms and telephones.

The rounds include checking all areas of the ship with mechanical apparatus and ensuring that the necessary gauges, meters, lights, fluid level, and valves are within acceptable parameter and have not changed significantly or unexpectedly. As part of their inspection, engineers listen to engines, motors, fans, and pumps for unexpected or strange sounds. Along with this visual and auditory inspection of the ship's machinery, the watchkeepers feel equipment for temperature, security, and unexpected or strange vibration. Watchkeepers must also be aware of unusual occurrences such as leaking fluid or air, improper appearance or discolouration of fluids, and loose or damaged equipment.

If an irregularity is noticed, the watchkeeper must attempt to determine the cause, solve the problem, and make other members of the crew aware of it. The cause of the problem may be new, or one that is recurring. In order to arrive at a solution to a recurring problem, the watchkeeper must assess the problem relative to it's last occurrence. Once this is done, the watchkeeper may be able to solve the problem using the previous solution (or a variation of it) or he may be required to find an entirely new solution. For new problems, the watchkeeper may be able to use a solution to other, or related problems, or he may be required to find an entirely new solution. The decision of whom to make aware of the problem rests initially with the person who discovers it. Once others are aware of the problem they are included in, and may take over, the decision making and repair process.

Other duties of engine room watchkeepers include communication with the bridge, maintaining the engine room log, fog and ice standby, responding to control room alarms and general maintenance which includes such tasks as painting and cleaning.

1.6.2 Communicating with the Bridge

Radio and telephone communication between the bridge and engine room is essential to ensure that the vessel is prepared for upcoming mechanical requirements. Bridge crew must be informed of power capabilities to ensure the vessel does not engage in activities for which it does not have enough power. The engine room watchkeepers communicate this information to the bridge when significant power or course changes are required and receive verbal confirmation that this information has been received. Improper communication may affect overall vessel performance and safety. Levels of communication between the bridge and the engine room increase while maneuvering through ice, icebreaking and during ice escort and SAR.

1.6.3 Maintaining the Engine Room Log

The engine room watchkeepers are required to maintain a detailed and accurate log of maintenance activities. The log is updated every hour, or if there is a significant event. As with the ship's log, the log is handwritten and during a period of high activity such as SAR, poor weather or high sea states there is more use of abbreviated entries. Failing to maintain an accurate engine room log increases the potential for subsequent mechanical failure, which places the vessel at risk, as well as having inaccurate records of ship's activities for future reference. Maintaining the engine room log involves compiling appropriate maintenance and event information, tabulating the data in the proper format, and integrating information into the final report form.

1.6.4 Fog and Ice Standby

Fog and ice standby periods may occur at any time during the patrol or watch. This requires at least one watchkeeper to remain in the engine control room to answer requests from the bridge or respond to alarms. Although the watchkeeper on standby may be called upon infrequently, the call is usually a critical situation, such as a loss of power an engine or loss of overall ship's power. During standby periods the watchkeeper usually has little work to occupy his time, and long standby periods may last the entire watch.

1.6.5 Responding to Control Room Alarms

Responding to control room alarms involves hearing the alarm when not in the control room and proceeding to the control room to determine the cause of the alarm. Once the cause of the alarm has been determined, the watchkeeper must attempt to resolve the problem. The alarm may be the result of a familiar problem, one the watchkeeper has seen recently or some time ago, or the alarm may be the result of a new problem.

1.7 Influences of modes of operation on task characteristics

Depending upon the mode of operation, task characteristics can change considerably. On icebreakers, maneuvering through ice, icebreaking , ice escort and SAR are modes of operation where the frequency and criticality of some tasks can increase.

1.7.1 Maneuvering Through Ice

When maneuvering through ice, the workload of the navigator, helmsman and engineering crew increase significantly. During this time, the helmsman is always in direct control of the vessel while he scans the water from the bow to the horizon searching for the best route. The strategy is to work in conjunction with the navigator to steer through the leads, based on criteria established by the captain while avoiding bigger, older ice as much as possible. Engineering crew must be particularly vigilant and prepared to respond immediately to the requirements of the bridge. Strategies for maneuvering through ice are discussed between the helmsman, navigator and other bridge crew (i.e., the captain and the first officer). The frequency and criticality of these discussions depends on the situation. Factors which play a significant role include ice conditions, weather, visibility, time of day, the urgency of the mission and whether the ship is escorting another vessel. For example, escorting a tug in fog through heavy, thick ice that is under high pressures, as a result of wind force, would be more critical than moving through thinner ice in clear weather with no tug to escort. In the former case the frequency and criticality of the discussions and decision making processes are increased.

The act of maneuvering the ship through leads is also a dynamic process. As the ship follows one lead and the ice moves, the ship's position changes relative to other leads. If the ship is to effectively traverse the ice, the bridge crew (including the helmsman and navigator) must remember and anticipate the relative positions of the ship and the best leads, as well as being aware of the ship's location relative to the planned course.

During this time the helmsman is still responsible for communicating with the navigator with respect to the heading of the ship, so that the navigator can evaluate the position relative to the charted route. When maneuvering through ice, the best leads may take the vessel away from the planned route. Once the vessel is near the limits of the allowable deviation set by the captain, the ship cannot be steered further in that direction without authorization from the captain. At this time, communication with other bridge crew becomes more critical.

1.7.2 Icebreaking

The captain normally assumes control of the ship and the ship's throttles when icebreaking because the level of danger to the vessel increases dramatically. The navigator usually assists the captain in maneuvering the vessel by indicating objects that the captain may be unable to see, communicating with escorted and other vessels, and contributing to strategy discussions while carrying out normal duties. The bridge is in continuous contact with engineering so that the changing power and mechanical requirements of the vessel can be accommodated as quickly as possible.

When icebreaking, the helmsman follows the orders of the commanding officer on the bridge. The officer will indicate where he wants the ship to hit the ice by pointing to the point of contact, describing the point of contact, indicating an angle relative to the ship using "points off the bow" (one point equals 11 and 1/4 degrees) and a distance using cables (one cable equals approximately 600 feet), a rudder angle, a heading or a combination of these directional indications. The helmsman verbally confirms this information and sets the rudder angle to hit the ice at the desired point of contact. After the ship has contacted the ice, the helmsman must determine when the ship has stopped moving forward and return the rudder angle to zero, or "midships". He then indicates verbally to the commanding officer that the wheel is at midships. To effectively accomplish these goals, the helmsman must be aware of the throttle position (forward or reverse) as well as wind speed and direction. The position of the throttle is the cue for the helmsman to know when the ship will stop moving forward. Wind speed and direction may affect where and how the ship will strike the ice.

1.7.3 SAR

All CCG vessels have a requirement to carry out SAR. During a SAR incident, the centre of activity is the ship's bridge. Bridge operations are complex and involve the coordination of numerous tasks by a small team of highly trained crew members. At a high skill level, bridge activities include: maintaining a lookout; conning or steering the vessel; navigating; and maintaining communications with the engine room, other members of the bridge team and points of contact external to the vessel. The size and composition of the bridge crew and the distribution of tasks can vary according to the particular mode of operation relative to the SAR tasking. The modes include: SAR standby; steaming watch; on scene; commencement of search; deployment of FRC; being an asset to another search; and on scene commander.

Bridge activities intensify during a SAR incident, which increase the workload and operator stress as a result of increased information processing demands. This can result from greater concentration on visual search, and increased demand on navigational skills to establish and maintain effective search patterns. Depending upon characteristics of the particular incident as well as available equipment and personnel resources, the latter may include coordinating search efforts with other vessels or aircraft. During a SAR incident, engineering crew must be particularly vigilant and in continuous communication with the bridge in order to respond as quickly as possible to the changing power and mechanical demands of the vessel.

The demands of a SAR incident can be both mentally and physically intense. The requirements when on scene can be difficult to anticipate before arriving and may require crew members to carry out multiple taskings and to solve unique problems without exposing the vessel and crew to excessive danger. SAR frequently takes place during the most adverse sea and meteorological conditions, as such conditions are often responsible for the incident.

1.8 Fatigue Effects and Task Performance for Bridge and Engineering Watchkeepers

As discussed in Section 1.0, certain types of tasks or task components are particularly sensitive to fatigue effects, in terms of their potential to produce performance deficits which in turn increase the risk to crew members and vessel safety. During routine operations, task performance with highly trained crew is somewhat resistant to stress effects related to fatigue. However, when the demands on the crew are high and task characteristics become more complex and less routine, fatigue effects are of greatest concern. On icebreakers, demands on the crew intensify when maneuvering through ice, when icebreaking and during ice escort and SAR. In addition, demands on the crew increase considerably if the vessel is exposed to heavy weather and high sea states. During these time, tasks that are particularly prone to disruption are ones with the characteristics listed below. If these tasks are carried out at night, when circadian rhythms are at a low, they pose further risk to crew performance and vessel safety. Of particular concern are:

- Long duration tasks: e.g., searching for leads, SAR lookout, conning the vessel, engineering standby;
- Tasks where there is limited or delayed feedback in terms of how well they were carried out: e.g., conning the vessel (particularly if only one steering pump is in use), navigation with reduced visibility, certain aspects of equipment repair;
- Physically and mentally demanding tasks: e.g. equipment repair, coordination of communications, simultaneous bridge taskings;
- Tasks which need to be completed within strict time frames (externally paced): e.g., course plotting especially if navigating close to shore, engineering watchkeeping rounds;
- Tasks that are being carried out by less experienced crew;
- Mentally complex tasks: e.g., navigation, on scene commander during SAR, equipment repair; and responding to alarms;
- Physically complex tasks requiring good coordination: e.g., working in high sea states;
- Tasks that require extensive use of short term memory: e.g., bridge communications and bridge to engineering communications, conning through ice, SAR coordination, equipment repair, position fixes (range and bearings);
- Tasks which may be mundane and boring: e.g., lookout duties, fog and ice standby in engine room.

APPENDIX J

Coping Strategies

1 STRATEGIES AND INTERVENTIONS TO COPE WITH WATCH SCHEDULING

1.1 Recommendations to Improve Sleep when Working Watches

There is no quick fix solution for how to fall asleep and how to sleep well. Everyone is different. You should be patient and see what works best for you. This may require a little time as well as some trial and error. However, it's worth it once you find the system that best works for you. The following are some suggestions:

1. ***When to sleep after a night watch.*** You need to find your own best time for sleeping in the daytime. This may be straight after night watch, immediately before night watch or part of both. Morning sleep gives you the advantage of a free afternoon. Sleeping in the afternoon or early evening gives you that extra restfulness before work.

2. ***How long to rest between night watches.*** You should give yourself about 7 hours in bed or resting, whether you sleep or not. Some individuals can rest and recover simply by relaxed rest and not complete sleep.

3. ***How long to sleep as a minimum.*** Try to get at least four hours of sleep. Some studies have found that people who were allowed to sleep for four hours per day on three consecutive days, were able to achieve 90% of their normal performance levels.

4. ***Can you learn to live with reduced sleep?*** You should give yourself a lot of time to get used to reduced sleep when starting night watch for the first time, or after a long break. You may find yourself more drowsy than usual. Experienced watch personnel seem to get used to living with less sleep instead of learning to sleep longer.

5. ***Should I become a night owl?*** When you are on permanent nights, try to make an effort of becoming a night person. This means getting up as late in the morning as you can, going to bed late, staying indoors during the morning, and trying to stick to your old meal system if you can.

6. ***Should I take naps at work?*** If you are allowed to take naps at work, make sure they are not too short. If your nap is too short you may experience sleep inertia. This is the grogginess and state of confusion that you feel after being woken up after too short of a sleep. This could have serious consequences at work if you are woken up and expected to deal with an emergency. However,

some studies have shown that a nap as short as 20 minutes may help to overcome severe attacks of uncontrollable sleepiness.

7. ***Your ears.*** Ear plugs are very effective in blocking noise. You can get them at a pharmacy or hardware store. However, you should make sure your alarm or "shake" is loud enough to wake you up.

8. ***The darker the better.*** Light from the sun really creates problems when you are trying to sleep. Melatonin, a hormone which induces sleep has a circadian rhythm. Exposure to light inhibits this hormone. Therefore, making sure it's dark in your bedroom and avoiding light will help you to fall asleep. Heavy curtains and an eye-mask really help.

9. ***Getting the right air.*** Fresh air in the sleeping area before you sleep should help you fall asleep. Sleep is best at about 15 to 18 degrees Celsius.

10. ***Keep your sleep rituals.*** Go through the same rituals of going to bed as you usually do before night sleep. Brushing your teeth and putting on sleeping clothes may help you feel ready for sleep. A warm bath or shower may also help you to feel sleepy.

11. ***What about eating?*** Try to stick to normal mealtimes if possible because a sudden change in diet can disrupt your sleep. Too heavy or spicy a meal before bed may wake you, and so may hunger. Not eating in the last two to four hours before bedtime may help.

12. ***What about drinking?*** In the last few hours before ending your watch, drink less than usual. The human bladder usually has an emptying frequency with a day rhythm. Therefore, sleep is more likely to be interrupted by the need to urinate. Reducing the amount of fluid intake gives your bladder less stimulus to work. Avoid caffeine (coffee, tea, cola, chocolate and some pills) two hours before sleep. Ideally, caffeine should be avoided for at least five hours before trying to go to sleep. A warm glass of milk before bed has been found to help sleep quality.

13. ***Check the quality of your bed.*** Beds often deteriorate over time. Upgrade your bed if it's in poor condition. The mattress should be firmly sprung, with no sag.

14. ***Should you relax between work and bed?*** See whether you need time to wind down after work. It may be helpful to relax if you are usually tense. It may be wise to read or watch TV to calm down. This should be done somewhere other than in your bedroom.

15. ***Relaxation.*** Trying to get in the right frame of mind for sleep is important. If you have difficulties falling asleep, try gentle music, a relaxation tape or other relaxation techniques to help you sleep. Getting angry about not being able to sleep will only make it more difficult to sleep.

16. ***Avoid caffeine.*** As stated earlier, caffeine products should be avoided 5 hours before bed. Try some fruit juice if you need a bit of energy.

17. ***Be cautious of sleeping pills.*** The best sleep happens without sleeping pills. Sleeping pills can provide temporary relief of insomnia, but can have varied short and long term effects. Sleeping pills become less effective with regular use and can become addictive; use them only if you have to.

18. ***Do not use alcohol before bed.*** Alcohol is not a good aid to sleep. It may help you to fall asleep, but the sleep is of poor quality. Also, consumption of alcohol before bed causes early awakenings.

19. ***Don't combine alcohol and sleeping pills.*** Some sleeping pills intensify the effects of alcohol and vice versa. The combination of the two should be avoided.

20. ***Try to reduce smoking.*** Heavy smoking (2 packs a day) can disturb sleep. Nicotine is a stimulant that is capable of keeping you awake for 3 hours after your last cigarette. Therefore, a cigarette before trying to sleep may keep you awake, but quitting smoking all together may cause temporary sleep problems due to withdrawal.

21. ***When working morning watches, go to bed early.*** Many morning watches start early. When you consider washing, eating and other chores, sleep time can be greatly reduced if you do not go to bed at a reasonable time. Try to get 8 hours of sleep.

22. ***Try keeping a diary of your sleep.*** Keep a record of your sleep, its problems and successes. These guidelines may help you build up your experience and expertise more quickly. It will also provide a systematic way to recognize what is working well for you, and what needs to be worked on. Remember, you are the best expert on your own sleep.

1.2 Eating—9 Guidelines for Eating when Working Watches

Watch work changes meal times. The human digestive system, like sleep, has a 24-hour rhythm of activity and rest: a circadian rhythm. This can cause problems for watch personnel. The following are some guidelines that may help:

1. ***When to eat - in general.*** Try to eat meals at regular times every day. Irregular meal times can cause digestive problems.

2. ***When to eat when working night watch.*** Eat your meal before 01:00. Waiting to eat closer to your bedtime can cause digestive problems. Also be careful of what you eat as some meals can decrease your alertness.

3. ***What you should eat and where.*** You should try to have a hot meal in as normal a social situation as possible. This can help with digestion. Eating in a social situation can also help workers wake each other up.

4. ***What you should have for snacks.*** Fresh fruit and milk products make good snacks. Fruit is a good source of vitamins and its natural sugars give you quick energy. Milk and milk products are rich in proteins that are good building materials for your body.

5. ***What to eat on night watch.*** Try snack food that is rich in protein rather than carbohydrates. A protein snack will help compensate for a decline in alertness which may take place during the second part of the night.

6. ***What to avoid.*** Do not eat meals with more than 600 calories and that are high in fat content. Excessive calories can make you sleepy, while high fat content is hard on your stomach. Remember, your stomach does not expect to be working during the night hours. Your stomach's rhythm is more geared to working during the daytime. Therefore, try to eat low-fat meals.

7. ***When should you have your main meal?*** You should try having your main meal of the day immediately following your sleep. If you have time, you can take a nap or rest. By having your main meal in the late afternoon you may have the advantage of eating around the time of your normal digestive rhythms.

8. ***Try to figure out if you are eating correctly.*** Listen to your body, your stomach comfort and your energy levels. Also watch out for weight gain or loss. Be prepared to try changing your eating habits.

9. ***What you should do if eating problems continue?*** If you are experiencing frequent indigestion or stomach or bowel problems, contact your doctor.

1.3 The Role of Vitamins and Minerals

Nutrition plays a role in how you feel. You may find you are more alert when working night watches and that you can sleep better, depending on what you eat. Having a meal rich in protein boosts concentrations of chemicals in the brain which can stimulate activity. Eating meals rich in carbohydrates increases concentrations of serotonin, a sleep-inducing chemical in the brain. However, there are other vitamins and minerals that you should know about, especially if you are having difficulty sleeping. The following is a description of vitamins and minerals that can help you sleep:

1. ***The B vitamins:*** These vitamins regulate the body's use of amino acids, including tryptophan. Some studies have shown that Vitamin B-3, enhances the effect of tryptophan. Tryptophan is one of the 22 amino acids found in protein. Tryptophan is a precursor of the sleep-inducing brain chemical serotonin. Vitamin B-3 is reported to be effective in alleviating the type of insomnia suffered by people who fall asleep readily but who are unable to fall

back asleep after awakening later in the night. Vitamin B-3 is found naturally in high-protein foods such as fish, liver, kidney, chicken, peanuts, milk and eggs. Other research indicates that some sleep problems can arise from a deficiency in folic acid, which is a member of the Vitamin B family. Folic acid can be found naturally in asparagus, broccoli, cauliflower, cabbage, green peas, kidney and lima beans, beets, sweet potatoes, whole-grain cereals and breads, oranges, cantaloupe and organ meats. Loss of B vitamins from our body is increased by cigarette smoking, alcohol, birth-control pills and stress.

2. ***Calcium:*** This mineral, found naturally in milk and dairy products, is a relaxant that has a calming effect on the central nervous system. Some studies have shown that even a minor calcium deficiency can cause muscle tension and insomnia. If you are allergic to milk or just do not like it, try other natural forms of calcium, like mustard greens, dandelion greens, broccoli, spinach and sardines.
3. ***Magnesium and potassium:*** Magnesium (found naturally in potatoes, whole-grain bread, milk, meat, fish, poultry, eggs, dark green leafy vegetables and citrus fruits) is a natural sedative. Studies have shown that magnesium deficiency can cause insomnia. Potassium (which is found naturally in meat, milk, potatoes, bananas, oranges, apricots), in combination with magnesium has also been found effective in alleviating chronic fatigue.
4. ***Zinc:*** A deficiency in zinc can contribute to insomnia. This mineral can be found naturally in oysters, herring, meat, milk, eggs, whole grains, peas, beans, soybean curd, raisins, dried figs and apricots.
5. ***Iron and copper:*** Recent studies reported that a deficiency in either copper or iron has an effect on sleep patterns. Women who received insufficient amounts of copper or iron reported that they found themselves sleeping longer than usual and also waking more frequently during the night. They also reported that they would awaken tired and not refreshed. Copper can be found naturally in whole-grain cereals and breads, shellfish, nuts, organ meats, eggs, poultry, dried beans and peas and leafy dark-green vegetables. Iron is found naturally in organic meats and dark-green leafy vegetables, as well as in beef, sardines, oysters, prunes and other dried fruits, peas and lima beans.

1.4 Physical Fitness and Well-Being—5 Rules

Trying to stay healthy is important for several reasons. Many jobs do not provide the opportunity for the human system to maintain heart, lungs and muscles in good working order. The human body has evolved under a physically active life and stays healthier when there is some regular physical activity. Doing at least twenty minutes of exercise, three times a week tends to improve mood and increase resistance to stress. The following are some rules that can help with physical fitness and well-being:

1. ***Keep your stamina up.*** Try to take part in some physical activity. Aiming to raise your heart rate is a good start. This can be done by training for 20 minutes a day, 3 times a week. The purpose is to raise your heart rate from

its normal resting rate to a training-rate: a minimum of 180 minus your age (i.e., 140 for a 40-year old). Exercise which involves large muscle groups, like those in your legs, is quite effective.

2. ***Don't over do it.*** Do not exercise too strenuously before starting your night watch. You do not want to exhaust yourself before work.

3. ***Visit your doctor for an annual check.*** You should have a regular medical check-up, at least once a year. Many problems can be treated if detected early.

4. ***Check yourself out.*** Be aware of the gradual development of problems that may result from watch work such as, weight loss or gain, gastric or digestive problems, excessive fatigue or nervous disorders. These are early signs of ill-effects resulting from night work.

5. ***Take care of your life-style.*** Working different hours can lead to habits that contribute to poor health, like smoking, drinking caffeine or alcohol and dependency on sleeping pills. Keeping a diary of your life-style may help to warn you of any growing problem areas.

2 MORE STRATEGIES THAT MAY HELP

2.1 Relaxation Techniques

There are many relaxation techniques that may help you fall asleep. You may try experimenting with a variety to see which works best for you.

1. ***What's best for you?*** Meditation, yoga, abdominal breathing, autogenic training and progressive muscle relaxation are some forms of relaxation that may help you to fall asleep. Autogenic training will be discussed later. The main form of relaxation that will be discussed here is progressive muscle relaxation. This form of relaxation is simple to do and easy to learn.
2. ***How can relaxation help you in fall asleep?*** If you learn to focus your attention on relatively pleasant, monotonous, internal sensations then you won't be able to focus on worrisome thoughts and images that prevent sleep onset. This re-focusing may be the sleep-inducing mechanism rather than the actual tension that is released. Whatever the cause, relaxation techniques have proven to help with sleep onset.
3. ***What is Progressive Muscle Relaxation and How do you do it?*** Progressive Muscle Relaxation is a method of tensing and relaxing various muscle groups throughout the body. Beginning with your head and working down to your toes, contract each muscle group one at a time for twenty seconds. Make yourself aware of the sensation, then slowly relax, experiencing the relaxation for another twenty seconds. Then move down to the next muscle group and repeat the procedure. Contract the muscle group for twenty seconds, make yourself aware of the sensation, then slowly relax and experience the relaxation for twenty seconds. Then, move down again to another muscle group. At the very end, once you have done each muscle group, contract your whole body for 20 seconds and relax. Do this three times. You should spend about 15-20 minutes doing this exercise while lying in bed before trying to go to sleep. You can also do this in a chair during the day when feeling tense or stressed.

   Remember contract for 20 seconds, then relax for 20 seconds. Begin with the muscles in:

- your forehead
- jaw
- neck
- shoulders
- arms
- hands
- stomach
- upper legs
- lower legs
- feet & toes
- your whole body, 3 times

2.2 Cognitive Approaches: Ways of Dealing with Anxiety

Going to bed with a racing mind will almost guarantee you disturbed sleep, if any. It's a vicious cycle. Anxiety reduces your ability to fall asleep, which then causes further anxiety, which then perpetuates your inability to sleep. Cognitive strategies try to help you deal with your worrisome pre-occupations and aim to replace them with calmness. Constantly tossing and turning, the person who lies in bed cursing that they cannot sleep while thinking "I'm going to be a wreck tomorrow!" will perpetuate further anxiety, thus making sleep that much more difficult. Cognitive interventions try to focus on what people think and tell themselves, and correct irrational "catastrophizing" thoughts with calming ones. When you go to bed feeling anxious or when you go to bed with many thoughts racing through your mind, try some of the following:

1. ***Autogenic Training—***This is a technique that requires focusing your attention on various parts of the body (particularly your limbs), coupled with self-suggestions of heaviness and warmth.

2. ***Positive Self-Talk—***Try to have a positive attitude towards your sleep and try repeating the following points to yourself:

    a) I have set aside time to deal constructively with my problems tomorrow.

    b) If I awaken early tonight, I will not dwell upon it, but will remain relaxed with my mind in neutral.

    c) Nightly arousals are normal.

    d) Developing these poor sleep habits took time, so it will also take time for them to return back to normal.

Sometimes problems arise with sleep when people engage in activities at bedtime that are incompatible with falling asleep. For example, they use their bedrooms for reading, talking on the phone, watching television, snacking, listening to music, planning the next day's events or worrying. As a result, the bed and bedtime become cues for arousal rather than sleep. As mentioned above, this leads to anxiety and frustration when trying to fall asleep. The goal then is to help the person to fall asleep quickly and to maintain sleep. This is done by helping the person to associate the bed as a cue for sleep and reducing it as a cue for activities that might interfere with sleep. The following technique may help in this process:

3. ***Stimulus Control Training***

   a) Lie down to go to sleep only when you are sleepy.

   b) Don't use your bed for anything except sleep.

   c) If you find you cannot fall asleep in about 10 minutes after going to bed, get up and go into another room. Stay up as long as you want, read, listen to relaxing music, do things that are sedentary, then when feeling sleepy return to the bedroom to sleep.

   d) Remember, you want to associate your bed with falling asleep quickly; therefore, if you still cannot fall asleep after trying Rule "C" repeat it again.

   e) Set your alarm and get up at that same time every morning, regardless of how much sleep you got the night before. This will help your biological clock acquire a consistent sleep rhythm.

   f) If your problem is waking up but not being able to fall back asleep later in the night, apply these same rules.

2.3 Natural Biological Therapies

The following procedures are recommended in preparation for watch work at sea.

1. ***Sleep Restriction Therapy.*** Many studies have shown that sleep becomes robust once it has been deprived. The objective of Sleep Restriction Therapy is to do just that: deprive sleep. For this particular intervention, a Sleep Diary is very helpful. First, estimate the amount of time you think you sleep each night, for example, four hours (sleep does not include the amount of time you have stayed in bed trying to sleep, it only includes the time you think you have actually slept). Once you have established how much time you are sleeping, restrict your time in bed to that amount of time (i.e., four hours), whether you have slept or not. Once four hours have gone by, get out of bed to start your day. This of course will make you feel tired during the day. However, this is a temporary side effect that is to be expected. Once you feel you have slept for the complete four hours, you may add another 15 minutes to your time in bed. If you continue to sleep better and longer, then continue to add 15 minutes to your time in bed until you reach your desired length of sleep time. However, if you have a poor night's sleep, you should again decrease your total sleep time by 15 minutes until your sleep improves again.

2. ***Chronotherapy.*** This technique is good for watch personnel in order to improve sleep and may be useful to implement at home prior to boarding vessels, particularly when working night watches. The problem with the watch-worker is that he/she has irregular sleeping patterns. Therefore, when the watch-worker is ready to go to bed, the biological clock is in a state of

desynchronization. Chronotherapy is aimed at resetting your biological clock. Although Chronotherapy may sound similar to Sleep Restriction Therapy, there are differences. Chronotherapy does not restrict your amount of sleep time, but rather delays it. For example, if you sleep from 3:00 to 11:00 a.m., but would like to start sleeping from 11:00 p.m. to 7:00 a.m., you have to re-synchronize your biological clock over a period of time. This can be done by delaying your bedtime by 2 to 3 hours a night and sleeping for as long as you usually sleep. It is important to make this change in a forward direction. That is, if you usually sleep for 8 hours, from 3:00 to 11:00 a.m., your second night's sleep would be from 6:00 a.m. to 2:00 p.m. and so on until you are sleeping from 11:00 p.m. to 7:00 a.m. It's a slow process but has proven to be effective.

3. ***Light Therapy.*** Another intervention that follows the same premise as Chronotherapy is Light Therapy. This intervention is quite effective with watch personnel and is not usually as time consuming as Chronotherapy. The aim of Light Therapy is to re-synchronize the biological clock. Studies have shown that melatonin, which is a sleep inducing hormone, is inhibited by light. Melatonin levels increase throughout the night and decrease in the morning, usually when the sun comes out. Melatonin is part of the biological clock in that it has a consistent rhythm. By using artificial light and by changing the time of the light exposure, the sleep phase of the biological clock can be advanced or delayed. Presenting bright light at the time of awakening creates what the biological clock "thinks" is an early dawn, advancing the sleep phase. This means the sleep phase will occur earlier in the day. Presenting the light at night produces a delay in the sleep phase of the biological clock. This means the sleep phase will occur later in the day. These light exposures can last for up to four days, two hours a day, before synchronization takes place.

3 SOME FINAL IDEAS

3.1 Coping with Your Night Watch

When working the night watch there usually is a period of time when you think you may collapse because you are so tired. The hours around 3:00 to 6:00 a.m. are typically the most difficult hours to work. This is normally the time when your biological clock is telling your body that you should be sleeping. It is also the time when your body temperature and alertness are at their lowest points. There are some measures you can take to combat this time period slump.

1. ***Try to keep active.*** Keep physically and mentally active in the last two hours at work. The accumulation of tiredness and the lateness of the hour can be quite intense by the end of the watch. Therefore, keeping physically and mentally active can shake off drowsiness.

2. ***Drinking some kind of caffeine drink may help***. But try not to do this less than five hours before you go to sleep or the caffeine will still be in your bloodstream while you are trying to sleep.

3. ***Have enough rest and meal breaks.*** Avoid long stretches of time without a break. You should be able to take a short break every two hours or so to walk around, get some fresh air, get something to drink or eat, or use the washroom. A proper lunch break about half way through your watch is also important.

4. ***It may also be wise to avoid naps*** Between 3:00 and 6:00 am naps may confuse the biological clock into thinking that it's time for sleep. Also, sleep inertia can occur after a nap. Sleep inertia is a state of grogginess and confusion that is usually felt after not sleeping enough.

5. ***Schedule your tasks appropriately.*** Try to schedule the more boring and monotonous tasks earlier on in the watch and not in the latter part of the watch when you are feeling very tired.