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SLEEP PROBLEMS, HEALTH SYMPTOMS, AND TENSION/ANXIETY AND FATIGUE DURING WARTIME CRUISING IN A MODERATELY HIGH HEAT/HUMIDITY NAVAL ENVIRONMENT

Timothy P. Steele, LT, MSC, USN
David A. Kobus, LT, MSC, USN
Guy R. Banta, LCDR, MSC, USN
C. Glenn Armstrong, LCDR, MSC, USN

Naval Health Research Center
P.O. Box 85122
San Diego, CA 92138-9174

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Summary

Problem

Previous laboratory and field studies have determined that prolonged stress and fatigue can lead to human performance decrements (Hockey, 1983). However, there is a dearth of research examining the combined effects of multiple environmental stressors (e.g., extended operations and/or battle readiness conditions, imminent physical danger, high heat/humidity) on the health and performance of shipboard personnel. A preliminary study was conducted under such conditions in early 1988 (Congleton, Englund, Hodgdon, Palinkas, Armstrong, & Kelleher, 1988), however, the sample size was small, periods at battle readiness were relatively short (5-7 hours), and both temperature and humidity were mild during the period of the study.

Objective

The second in a series, this study was designed to continue the quantification of cognitive, behavioral, and physiological responses to sustained operations in a hostile theater of operations with the inclusion of high heat and humid conditions. This technical report presents the findings from self-report sleep, health symptoms, and psychological measures obtained during the months of September and October 1988 in the Persian Gulf. Additional findings from cognitive testing and physiological measurements will be addressed in subsequent technical reports.

Approach

A cross-sectional sample of officers and enlisted personnel aboard nine U.S. Navy combatant ships was surveyed. Shiptypes included two Guided Missile Cruisers (CGs), five Minesweepers (MSOs), one Guided Missile Frigate (FFG), and one Amphibious Transport Dock (LPD). Subjects completed a one-time questionnaire survey of sleep issues, health symptoms, and psychological measures of tension/anxiety and fatigue. A sub-sample of Combat Information Center (CIC), Engineering, and Topside watchstanders was selected for repeated measures over four days, and more extensive physiological and psychological testing.

Results

Conditions of high heat, humidity, imminent danger, and periods of extended General Quarters had lessened considerably from anticipated levels at the time of study implementation. Nevertheless, problems with falling asleep, poor quality sleep, sleep inertia, and sleeping on the job were found to affect, in general, approximately a quarter of the subjects surveyed. Nearly 37% of all personnel surveyed indicated severe fatigue on a subjective fatigue checklist. Mental Fatigue, Heat Distress, and Muscle Fatigue were the most frequently reported environmental health symptoms; however, the severity of such symptoms was relatively minor. CG and LPD crews reported greater Heat Distress and Muscle Fatigue than crews aboard MSOs and an FFG. Overall, tension/anxiety levels of the cross-sectional sample appeared to be within normal limits. Junior enlisted personnel, however, reported greater tension/anxiety than higher paygrade personnel. Repeated measures of sub-sample subjects' tension/anxiety and fatigue showed a decreasing trend over a three-day test period. The relationship between tension/anxiety and fatigue measures and an index of total health symptoms was significant ($R = .59$).

Discussion

As a result of moderating climatic conditions and a reduction in regional hostilities, the stressors of interest did not impact on health and psychological well being to the extent originally expected. Hence, the findings presented here serve largely to support and extend the results of the previous pilot study (Congleton et al., 1988). Inadequate and poor quality sleep remain problematic under wartime cruising conditions. The greater Heat Distress of CG and LPD crews can probably be attributed to greater heat produced by steam propulsion plants and marginally adequate cooling ventilation below decks, particularly in engineering and berthing spaces. Despite high heat in engineering spaces aboard the MSOs, greater access topside apparently afforded some breeze cooling effect. The relatively elevated level of tension/anxiety among junior enlisted personnel was probably related to inexperience with extended at-sea operations and uncertainty in a potentially hostile wartime environment. The decline over several days in sub-sample tension/anxiety and subjective fatigue is difficult to explain. Although adaptation to sustained operations may account for it, a more probable explanation may be some artifact of the research methodology. This phenomenon needs further study. The present findings provide a point of departure for further at-sea studies to be undertaken during more extreme climatic conditions.

Sleep Problems, Health Symptoms, and Tension/Anxiety and Fatigue During Wartime Cruising in a Moderately High Heat/Humidity Naval Environment

Timothy P. Steele, LT, MSC, USN
David A. Kobus, LT, MSC, USN
Guy R. Banta, LCDR, MSC, USN
C. Glenn Armstrong, LCDR, MSC, USN

Introduction

The study partially described in this report is the second in a series of shipboard operational studies designed to evaluate the psychological, physiological, and behavioral effects on human performance of sustained operations under stressful operational and environmental conditions. As discussed in the first study, hereinafter referred to as Study One (Congleton, Englund, Hodgdon, Palinkas, Armstrong, & Kelleher, 1988), the stress accrued through prolonged continuous operations can have deleterious effects on crew health, psychological well-being, and job performance. The findings from Study One, however, revealed only minimal evidence of cognitive performance decrement, negative mood changes, or increases in physiological indicators of stress (except for a decline in urine specific gravity, indicating inadequate hydration). Some evidence of physical strain was found based on self-reported health symptoms, yet, mean symptom severity was relatively low, and no increase in negative health symptom reporting was found during sustained operations. Similarly, responses to a sleep questionnaire indicated relatively poor sleep quality and inadequate rest, yet no marked ill-effects on performance were reported.

The somewhat unremarkable findings from Study One were attributed to several factors. First, although the study was conducted under conditions of imminent danger from hostile forces, the working environment of crewmembers was relatively benign. Potential environmental stressors such as high heat and humidity were not above tolerable thresholds during the period of the study. In addition, the durations of extended watches requiring high vigilance in the study were in the range of 5-7 hours. Apparently, given the relatively mild work environment and the nature of subjects' watchstation tasks, the lengths of observed watches were not sufficient to effect performance decrements. (It may also have been the case that the performance measures used were just not sensitive enough.) Although some evidence of minor transitory degradation was found on several study measures, the overriding conclusion of Congleton et al. (1988) was that study subjects demonstrated remarkable resilience to task demands and had adapted to conditions of sustained operations.

The purpose of this second study was to continue the quantification of cognitive, behavioral, and physiological responses to sustained operations in a hostile theater of operations under high heat/humid conditions. However, due to logistical and operational constraints, the three environmental stressors of primary interest (i.e., extreme heat, prolonged watchstanding, and imminent danger) were moderating considerably by the time the study was implemented. Maximal ambient temperatures in the naval theater of operations under study reach peaks in the range of 120 to 130 degrees Fahrenheit; relative humidity approaches 100%. The maximal ambient temperature at the time the study was conducted was 108 degrees Fahrenheit; the mean daily maximal temperature was 94.9 degrees Fahrenheit. The maximal relative humidity during the study period was 89%; the mean daily maximal relative humidity was 69.5%. The present report discusses the findings from self-report sleep, health symptoms, and psychological measures employed in the second study. Additional findings obtained from cognitive testing and physiological measurements will be addressed in subsequent technical reports.

Method

Subjects

A cross-sectional sample of 562 active duty sailors was obtained from nine U.S. Navy ships operating within the Persian Gulf during the months of September and October, 1988. Shiptypes included two Guided Missile Cruisers (CGs), five Minesweepers (MSOs), one Guided Missile Frigate (FFG), and one Amphibious Transport Dock (LPD). The cross-sectional sample from each ship represented a convenience sample of personnel readily available to fill out a questionnaire on either the first or second day the study team boarded the ship. Typically, upon boarding a ship, the Commanding Officer and Executive Officer were briefed in detail on the purpose and requirements of the study. Subsequently, department heads were tasked to cooperate in meeting appropriate resource requirements and to ensure reasonable representation of the crew during questionnaire administration. All study participants were volunteers who had been briefed on the purpose and methods of the study, and who had signed informed-consent forms. Mass testing was done in crews' messes. Table 1 provides a breakdown of the cross-sectional sample on the variables of age, paygrade, and occupational rating category by shiptype.

Table 1

Cross-Sectional Sample Demographics by Shiptype[a]

	TOTAL	CG	MSO	LPD	FFG
SHIP (N):	9	2	5	1	1
SAMPLE (N):	562	219	183	49	111
AGE (M):	25.6	24.4	26.3	26.1	26.6
PAYGRADE (%):					
E1-E3	31%	43%	22%	31%	22%
E4-E6	57%	52%	64%	53%	60%
E7-E9	6%	5%	6%	4%	10%
Officer	6%	2%	8%	11%	8%
OCCUPATIONAL RATING (%):					
Aviation	2%	0%	0%	8%	5%
Engineering/Hull	32%	29%	44%	6%	28%
Deck	29%	28%	24%	40%	33%
Admin/Clerical	18%	26%	16%	15%	10%
Electronics/Tech	11%	15%	6%	4%	14%
Medical	2%	1%	1%	15%	2%
Officer	6%	2%	8%	11%	8%

[a] "CG" = Guided Missile Cruiser; "MSO" = Minesweeper; "LPD" = Amphibious Transport Dock; "FFG" = Guided Missile Fast Frigate

For the purpose of obtaining more extensive and repeated measures, a sub-sample of individuals (n = 33) aboard six ships was also obtained. The sub-sample subjects were selected from watchstanders in the ships' Combat Information Centers (CIC) and Engine/Firerooms (Engineering), and from Topside lookouts or gunners. These subjects participated in physiological and cognitive performance testing as well as questionnaire testing. Engineering and

Topside watchstanders were of interest primarily to assess the effects of heat and sustained operations. CIC watchstanders were of interest as a control group for heat effects and to assess the effects of sustained operations. It should be noted that sub-sample subjects were identified by department heads who pre-briefed their subordinates and requested volunteers to participate. Interested individuals were then informed of all aspects of their participation by the research team and asked to commit to participate for the duration of the study. Of those who began the study, one decided to discontinue participation after the third measurement period. Table 2 provides a breakdown of sub-sample demographics by shiptype.

Table 2

Sub-Sample Demographics by Shiptype

	TOTAL	CG	MSO	LPD	FFG
SHIP (N):	6	2	2	1	1
SAMPLE (N):	32	12	8	7	5
AGE (M):	22.9	21.7	24.1	22.9	23.1
PAYGRADE (%):					
E1-E3	38%	25%	25%	57%	60%
E4-E6	59%	67%	75%	43%	40%
E7-E9	0%	0%	0%	0%	0%
Officer	3%	8%	0%	0%	0%
WATCHSTATION (%):					
CIC (air/surface radar)	34%	42%	40%	57%	40%
Engine/Fireroom	44%	42%	20%	43%	20%
Topside/Gunner	22%	16%	40%	0%	40%

Measures

Measures relevant to the present report consisted of the Wet Bulb Globe Temperature (WBGT) Index (an index of thermal stress) and a questionnaire comprised of self-report items. Variable domains included in the questionnaire were sleep issues, health symptoms, and subjective measures of tension/anxiety and fatigue. The cross-sectional sample was surveyed once and, with the exception of sleep items, sub-sample subjects were measured repeatedly for up to four days.

WBGT Index. The WBGT Index is widely accepted in both military and civilian applications, and is obtained with an electronic meter that measures various combinations of ambient air temperature, radiant heat, convective heat loss, air movement, and humidity and directly computes a single index value (NAVMED-P-5010-3, 1974). A direct relationship has been established between the WBGT Index and the duration of exposure that can be tolerated by personnel at various levels of physical exertion. This relationship is operationally defined by Physiological Heat Exposure Limit (PHEL) curves which map various physical activity levels against the WBGT Index and exposure time limit coordinates (NAVMED-P-5010-3, 1974). For example, using the PHEL curves, the approximate WBGT Index values of 85, 94, and 99 are associated with three-hour stay-times for heavy, moderate, and light work levels, respectively. (PHEL curves for practical application are reproduced in Appendix A.)

Sleep Items. A subset of the Naval Health Research Center Sleep Questionnaire (Naitoh, Englund, Ryman, Hodgdon, 1984) was employed to assess subjects' sleep practices, problems, and attitudes. All sleep questions were single item measures. (Appendix B contains a copy of all sleep items and provides cross-sectional sample response percentages.)

Health Symptoms. The Environmental Symptoms Questionnaire (Kobrick & Sampson, 1979) was used to evaluate the health status of the samples. This 52-item survey consisted of a comprehensive list of physiological symptoms likely to be associated with environmental extremes. For the purpose of item reduction and identification of symptom clusters, a principal components analysis with oblique rotation was conducted using the cross-sectional sample data. Fourteen factors emerged with eigenvalues greater than one, accounting for 66% of the variance. One factor was eliminated from further consideration because it was primarily a measure of global affect rather than a physiological symptom cluster. Scale reliability analyses were performed, and items with corrected item-total correlations less than .40 were dropped from scale inclusion. Composite symptom scales were created by computing the mean of the remaining items comprising each scale. All composite scores range from 0 to 9 with higher scores indicating more severe symptoms. Table 3 lists the final Environmental Symptom Composites (ESCs), estimated scale reliabilities (Cronbach's alpha), and ESC intercorrelations. Appendix C contains a list of the items comprising each ESC.

Two additional measures were developed to further assess the health status of personnel: (1) the percent of the sample reporting the presence of a specific composite (i.e., an ESC score > 0) was calculated, and (2) a total environmental symptom score (ESCTOT) was computed as the mean of all the ESC scores (Cronbach's alpha = .80).

Subjective Anxiety and Fatigue Measures. Two instruments each were used to assess subjective anxiety and fatigue of subjects. The Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971) Tension/Anxiety (POMS-TA) and Fatigue (POMS-F) subscales were used as in Study One. The POMS subscales were designed to measure respective momentary mood states at the time of scale administration. Mood state refers to an emotional state which is transient and responsive to changes in the environment. Hence, the POMS subscales were suited to assessing the psychological effects of various stressors over time. POMS-TA scores can range from 0 to 36. POMS-F scores can range from 0 to 28. Higher scores indicate greater distress.

In addition to the POMS-TA, a 20-item State Anxiety (SA) scale (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used to obtain a supplemental assessment of tension/anxiety. The SA scale measures subjective feelings of tension, apprehension, nervousness, and worry at the time of administration. SA scores can range from 20 to 80 and higher scores indicate greater anxiety.

The U.S. Air Force School of Aviation Medicine Subjective Fatigue Checklist (SAM-F; Pearson & Byars, 1956) was also administered to subjects to supplement the POMS-F measure of fatigue. The SAM-F, employing a 7-item Guttman scale, describes the individual's general feelings of energy, alertness, and fatigue. SAM-F scores can range from 0 to 14. However, unlike the POMS-F, a lower score on the SAM-F indicates greater fatigue; a higher score indicates greater liveliness.

Table 3

Environmental Symptom Composite (ESC) Inter-Correlations[a] and Reliabilities[b]

	Composite	1	2	3	4	5	6	7	8	9	10	11	12
1	Mental Fatigue	.82											
2	Heat Distress	.42	.72										
3	Muscle Fatigue	.56	.39	.72									
4	Eye/Sight Problems	.50	.32	.42	.66								
5	Headache	.38	.28	.41	.43	.72							
6	Ear/Hearing Problems	.33	.27	.36	.34	.28	.60						
7	Nasal Distress	.25	.14	.22	.25	.25	.29	.57					
8	Gastrointestinal Distress	.30	.28	.34	.36	.46	.28	.21	.73				
9	Respiratory Distress	.36	.27	.36	.42	.46	.36	.27	.35	.81			
10	Coordination Problems	.34	.22	.40	.40	.31	.29	.19	.37	.34	.80		
11	Chills	.18	.06	.17	.23	.24	.22	.10	.29	.26	.17	.75	
12	ESC Total Symptom Composite	.74	.62	.75	.71	.65	.57	.46	.59	.67	.61	.39	.80

[a] Correlations are based on pairwise deletion of missing values, hence, n varies from 521 to 534.
[b] Diagonal coefficients are Cronbach's alpha estimates of internal consistency.

Procedure

As noted previously, questionnaire data were collected from the cross-sectional sample on either the first or second day aboard ship. In most instances, the research protocol for sub-sample subjects began on the second day aboard ship. In addition to obtaining questionnaire data from sub-sample subjects, as ships' operating schedules allowed, cognitive performance and physiological data were collected both pre- and post-watch, every other day, for up to four days (i.e., eight maximum survey measurement sessions). On test days WBGT readings were taken hourly at all Engineering and Topside watchstander sites during the course of subject's watches ($\underline{n}$ = 21). Sub-sample subjects stood normal duration watches, and watch rotations were altered only slightly to facilitate concurrent assessment of subjects.

For the duration of the study all ships operated in Condition III (wartime cruising readiness). At no time did any of the ships go to General Quarters (GQ; battle readiness). Although it may have enhanced a sustained operations effect to have simulated extended GQ, especially to obtain effects on repeated measures of sub-sample subjects, such an approach was problematic and not within the prerogatives of the research team. As was the case in Study One, circadian cycles were not controlled for in this study.

Data Analysis

The analytical strategy of the present study followed three basic steps. First, baseline descriptive statistics were calculated for both the cross-sectional and sub-sample subjects. Second, exploratory analyses were conducted to identify individual or operational discriminators of cross-sectional sample dependent variable measures. Third, repeated measures analyses were conducted on sub-sample subjects to assess for pre- and post-watch and sustained operations effects. Although, in general, it was anticipated that sustained operations and high heat would have detrimental effects on sleep, health status, and subjective psychological measures, the analyses undertaken utilized methods to reduce multiple comparisons, such as item-reduction and multivariate analyses of variance. It should be mentioned that due to missing data (primarily because of operational constraints), sample sizes varied across analyses. The approach taken was to include all cases with data relevant to a given analysis.

Results

WBGT Index

Mean daily WBGT Index readings were calculated for each Engineering and Topside watch location. Oneway analysis of variance (ANOVAs) and multiple comparisons were then conducted to assess differences within Engineering and Topside watches across shiptypes. Results (shown in Table 4) revealed that each shiptype differed significantly from each other shiptype for both Engineering and Topside watches. The mean WBGT Index for Engineering watches was highest on the LPD, followed in descending order by the MSOs, CGs, and lastly, the FFG. These results reflect the heat generated by the types of propulsion plants and auxiliary equipment aboard the ships studied. The CGs and the LPD used steam propulsion plants, the MSOs were diesel powered, and the FFG was gas turbine powered. The comparatively low mean WBGT Index value for the Topside watchstations aboard the FFG were a result of frequent 15 to 20 knot operations and resultant cooling winds across unshielded watch locations.

Table 4

Multiple Comparisons of Sub-Sample Engineering and Topside Watch Location Daily Mean WBGT Index Values by Shiptype

				Subgroup Means[a]			
Watch Location	F	(DF)	Signif.	CG A	MSO B	LPD C	FFG D
Engineering	40.37	(3,11)	$p < .001$	90.29_{BCD}	94.58_{CD}	99.36_{D}	86.05
Topside	26.20	(2,4)	$p < .01$	88.83_{BD}	87.09_{D}	---	84.90

[a]Subscripted means are significantly different ($p < .05$, Duncan method) than the subgroup denoted by the subscript. Note only nonredundant differences are denoted.

Sleep Problems

Descriptive frequency analyses of cross-sectional sample sleep surveys indicated that 22% of all subjects often or almost always had problems falling asleep. For 81% of those who indicated such frequent trouble falling asleep, this occurred three or more times per week. Additionally, in this group the most frequently indicated reason for having trouble falling asleep was "thoughts running through my mind" (65%); the second most common cause was "too much noise" (13%). Only 24% of the cross-sectional sample indicated that they often or almost always felt well-rested after first waking. Sixteen percent of all subjects reported feeling "foggy" and 26% indicated they were "sleepy," "fighting sleep," or "almost asleep" for up to three hours after awakening from normal sleep. Consistent with the foregoing sleep problems, 38% of the total cross-sectional sample reported sometimes falling asleep on the job even though trying hard to stay awake; an additional 10% of the total sample admitted that this was often or almost always a problem for them.

Kruskal-Wallis analyses of variance of the above sleep items were conducted for the independent variables of shiptype, occupational rating category, and paygrade. No significant differences were found across shiptypes. A significant difference was found among occupational rating categories for those subjects reporting that they often, almost always, or always have trouble falling asleep ($^{2}[6] = 15.75$, $p < .05$). The distribution of subjects reporting this problem was: 6% Officers, 11% Aviation, 12% Electronics/Ordnance, 19% Admin/Clerical, 24% Deck, 29% Engineering/Hull, 39% Medical.

A significant difference was found among paygrades ($^{2}[3] = 14.35$, $p < .01$) for those subjects reporting only sometimes, almost never, or never feeling well-rested after waking (50% E7-E9, 76% E4-E6, 78% Officers, 81% E1-E3). Differences were also found among paygrades ($^{2}[3] = 9.83$, $p < .05$) for individuals indicating they felt sleepy, were fighting sleep, or were almost asleep up to three hours after waking from normal sleep on workdays (16% E7-E9, 22% E4-E6, 25% Officers, 34% E1-E3).

Health Symptoms

Frequency counts of the presence of each ESC in the cross-sectional sample produced a rank ordering of the most commonly occurring health symptoms. Percentages reporting the presence of the five most prevalent ESCs were: 78% Mental Fatigue, 61% Heat Distress, 45% Muscle Fatigue, 34% Eye/Vision Problems, and 33% Headache. Table 5 provides a listing of the cross-sectional sample and the sub-sample baseline of subject response percentages for each

ESC, the mean severity score for each ESC, and a mean severity score for each ESC which includes only those subjects indicating the presence of the particular ESC.

Table 5

Cross-Sectional and Sub-Sample Health Symptoms Descriptive Statistics

	Cross-Sectional Sample (n=509)			Sub-Sample (n=32)		
Health Symptom Composite	Percent with Symptom	Mean[a] Severity Score-1	Mean[b] Severity Score-2	Percent with Symptom	Mean Severity Score-1	Mean Severity Score-2
Mental Fatigue	79%	1.85	2.35	66%	1.27	1.94
Heat Distress	61%	1.58	2.60	63%	1.00	1.60
Muscle Fatigue	45%	.97	2.15	50%	.93	1.85
Eye/Sight	34%	.62	1.85	28%	.35	1.26
Headache	32%	.44	1.34	31%	.31	.98
Ear/Hearing	23%	.31	1.32	13%	.15	1.18
Nasal Distress	19%	.40	2.10	13%	.17	1.38
Gastrointestinal	18%	.31	1.71	16%	.13	.80
Respiratory	15%	.18	1.18	16%	.21	1.33
Coordination	11%	.27	2.38	27%	.38	1.33
Chills	9%	.12	.70	13%	.16	1.25
ESC Total Symptoms	91%	.64	.70	84%	.46	.54

[a]Mean severity score of all cases in respective sample.
[b]Mean severity score of only those cases in sample reporting presence of symptom.

Multivariate analyses of variance (MANOVAs) were conducted to determine if shiptype, occupational rating category, or paygrade was associated with the five most frequently reported ESCs and with ESCTOT. Only the MANOVA for shiptype was significant ($F[18,1400] = 4.94$, $p < .001$). Subsequent univariate ANOVAs indicated significant differences among shiptypes for Heat Distress, Muscle Fatigue, and ESCTOT. Duncan's multiple range test was used to evaluate all possible pairwise comparisons. (See Table 6.) The CG and LPD crews reported significantly greater Heat Distress than both the MSO and FFG crews. LPD personnel indicated greater Muscle Fatigue than both MSO and FFG personnel, and CC respondents also indicated greater Muscle Fatigue than FFG respondents. The CG sample had a significantly higher ESCTOT score than the other shiptypes. Consistent with WBGT Index findings, the type of propulsion plant may have been one design characteristic differentiating the CGs and the LPD from the FFG that might partially account for these results. Combined with relatively poor air conditioning and ventilation, crews aboard the CGs and the LPD, particularly those working in engineering spaces and below decks were more likely to experience uncomfortably hotter conditions.

Table 6

Significant Cross-Sectional Health Symptom Composite Differences Among Shiptypes

			Shiptype Means[a]			
Composite	F(3,511)	Signif.	CG A	MSO B	LPD C	FFG D
Heat Distress	19.17	$p < .001$	2.22_{BD}	.97	1.97_{BD}	1.07
Muscle Fatigue	3.46	$p < .05$	1.11_{D}	.83	1.42_{BD}	.68
ESC Total Symptoms	2.85	$p < .05$	$.73_{B}$	.56	.72	.64

[a]Subscripted means are significantly different ($p < .05$, Duncan method) than the ship/s denoted by the subscript. Note only nonredundant differences are denoted.

Engineroom watchstations in the MSOs reached higher temperatures than those of the CG and the FFG (see Table 4). However, the proportion of the total crew required to stand watch in the MSO enginerooms was quite small. Additionally, given the nature of MSO operations, the majority of MSO personnel were involved in evolutions on the weatherdecks with a typically cooling breeze. This could at least partially explain the finding of less Heat Distress aboard the MSOs than the CGs.

A review of the baseline ESC scores for the sub-sample subjects in Table 5 reveals the same five most prevalent symptom composites as identified from the cross-sectional sample (66% Mental Fatigue, 63% Heat Distress, 50% Muscle Fatigue, 31% Headache, 28% Eye/Vision Problems). A t-test comparison of ESCTOT means for the cross-sectional sample and the sub-sample indicated that the two groups of subjects did not differ significantly on this index of total health symptom severity.

To assess the relationship between sub-sample WBGT Index values and post-watch Heat Distress, Pearson correlations were computed for these variables for each test day. The mean correlation was .30. This relationship was considerably lower than anticipated, and was probably a result of the timing and location of administration of the ESC questionnaire. The ESC questionnaire was typically administered in an air conditioned space anywhere from 15 minutes to an hour following relief from watch. In effect, subjects were tested after a cool-down period, thus precluding assessment of on-watch health symptoms. To the extent a cool-down period reduced potential Heat Distress scores or other health symptom scores, it appears that any moderate to severe watch related ill-health effects were relatively transitory.

A repeated measures MANOVA was conducted to evaluate sustained operations effects manifested in pre- and post-watch differences over three testing days. The fourth test day was not included due to insufficient data. Dependent variables in the analysis were the five most prevalent ESC severity scores and ESCTOT. Between subjects variables were watchstation (i.e., CIC, Engineering, Topside) and shiptype. Within subjects factors were test-day and pre-post watch. Only the main effect for shiptype was found to be significant ($F[18,43] = 2.38$, $p < .01$). No significant interactions were found. Subsequent univariate ANOVAs using ESC scores averaged over the six test sessions as the respective dependent variables revealed the shiptype effect applied to Heat Distress only ($F[3,20] = 3.02$, $p < .05$). Duncan's multiple range test (alpha = .05) indicated that LPD sub-sample subjects experienced significantly greater symptoms of Heat Distress over time than both FFG and CG sub-sample subjects. Given the small number of subjects per ship, an examination of subjects' individual mean scores indicated that the large difference between the LPD and the other shiptypes was due primarily to one CIC watchstander reporting uniquely high Heat Distress aboard the LPD. Removal of this subject's data from the analysis nullified the significant difference. Resultant Heat Distress overall mean scores for each shiptype were: FFG = .0667, CG = .3833, MSO = .4167, LPD = .7917.

Subjective Tension/Anxiety and Fatigue

Subjective scale intercorrelations and reliability estimates are provided in Table 7. Comparisons using t-tests identified significant differences between the cross-sectional sample and the sub-sample on all subjective psychological scales except SA, which approached significance ($p < .06$). In all instances sub-sample subjects reported less fatigue and less tension/anxiety than the cross-sectional sample subjects. This result may have been due to a self-selection factor in the sub-sample subjects or a manifestation of the Hawthorne effect due to increased individualized attention. Table 8 lists the cross-sectional and sub-sample subjective scale descriptive statistics.

Table 7

Subjective Psychological Measure Inter-Correlations[a] and Reliabilities[b]

Scale	1	2	3	4
1 State Anxiety	.93			
2 POMS - Tension/Anxiety	.76	.87		
3 POMS - Fatigue	.55	.66	.91	
4 SAM - Fatigue[c]	-.46	-.43	-.59	.83

[a]Correlations are based on pairwise deletion of missing values, hence, n varies from 519 to 534.

[b]Diagonal coefficients are alpha estimates of reliability.

[c]Higher scores on SAM-Fatigue indicate greater liveliness.

Table 8

Baseline Cross-Sectional and Sub-Sample Subjective Psychological Measures Descriptive Statistics

	Cross-Sectional Sample (n=518)	Sub-Sample (n=32)	
Measure	Mean (SD)	Mean (SD)	t(548)
State Anxiety	40.87 (11.08)	37.44 (9.66)	1.93
POMS - Tension/Anxiety	10.42 (6.80)	8.16 (5.20)	2.34*
POMS - Fatigue	9.62 (6.81)	6.14 (5.08)	3.68**
SAM - Fatigue	9.41 (4.05)	10.91 (4.14)	-1.99*

*$p < .05$; **$p < .01$

MANOVAs were conducted to evaluate potential differences among the cross-sectional sample psychological measure means across shiptypes, occupational rating categories, and paygrades. The MANOVAs revealed significant differences among the means for shiptypes and paygrades (respectively, $F[12,1352] = 3.67$, $p < .001$; $F[12,1328] = 1.75$, $p < .05$), but not for occupational rating categories. Subsequent univariate ANOVAs indicated that POMS-F means were significantly different among shiptypes and that SA and POMS-TA means were significantly different among paygrades. Duncan's multiple range test was then used to determine specifically which shiptypes and paygrades were different for the respective measures.

An examination of the results of the ANOVAs and multiple comparisons in Table 9 indicates that MSO crews reported significantly greater POMS-F scores than crews aboard the three other classes of ships. Sailors in paygrades E1-E3 reported greater SA and POMs-TA scores than all three higher paygrade categories evaluated in the study.

Table 9

Significant Cross-Sectional Subjective Psychological Measures Multiple Comparisons by Shiptype and Paygrade

SHIPTYPE

Measure	F(3,505)	Signif.	CG A	MSO B	LPD C	FFG D
			Subgroup Means[a]			
POMS-Fatigue	5.55	$p < .001$	9.25	11.18_{AD}	9.51	7.79

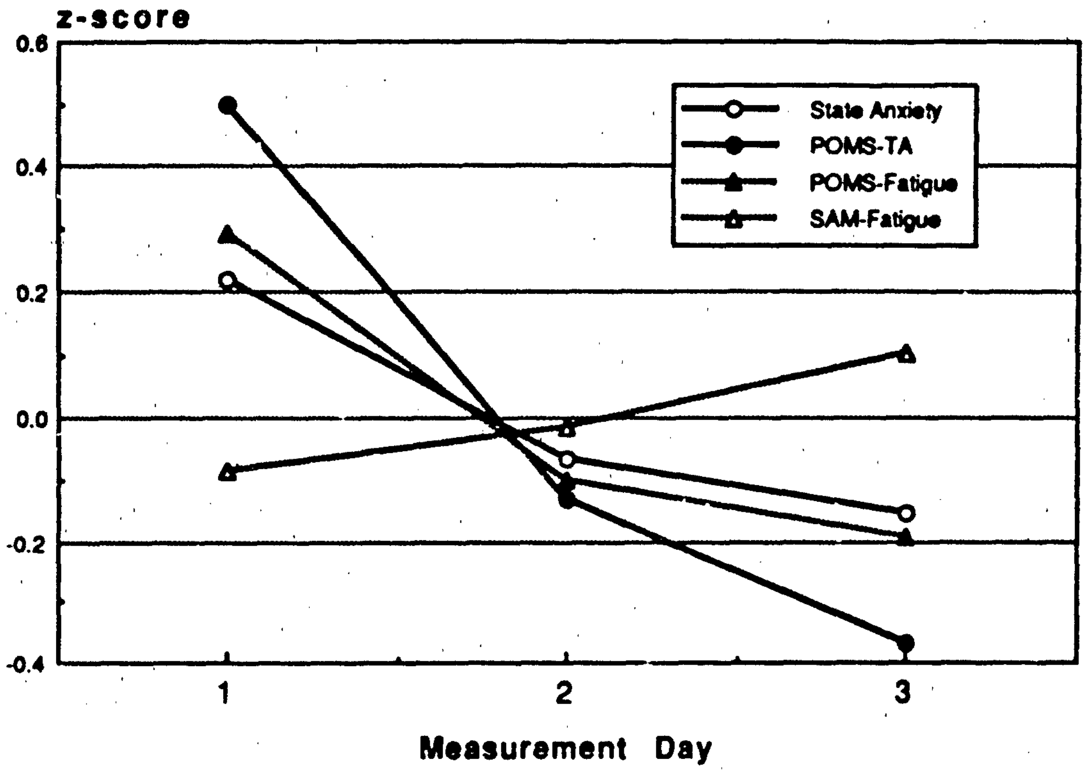
PAYGRADE

Measure	F(3,505)	Signif.	E1-E3 A	E4-E6 B	E7-E9 C	Officer D
State Anxiety	4.33	$p < .01$	43.03_{BCD}	40.61	36.69	37.97
POMS-Tension/ Anxiety	3.16	$p < .05$	11.57_{BCD}	10.12	8.72	8.63

[a]Subscripted means are significantly different ($p < .05$, Duncan method) than the subgroup denoted by the subscript.

A repeated measures MANOVA was computed using sub-sample data to assess the effects of sustained operations over three test days and pre-post watch-standing effects on the subjective psychological measures. The four psychological measures comprised the dependent variables in the analysis. Between subjects variables were watchstation location and shiptype. Results indicated a significant pre-post watchstanding effect ($F[4,17]$; $p < .001$) and marginally significant test-day effects ($F[8,13] = 2.65$; $p < .06$). Univariate tests of pre-post effects identified a significant difference for SAM-F only ($t[20] = 2.36$, $p < .05$; $\bar{x}$ pre = 11.65, $\bar{x}$ post = 10.08), indicating greater post-watch fatigue. Orthogonal polynomial contrasts of test-days revealed significant linear effects for the POMS-TA and POMS-F scales ($t[19] = -4.48$ and -2.11, respectively). Although only the above-mentioned two scales showed a significant linear effect, the pattern of decreasing distress over time (depicted in Figure 1 using z-scores) was present for all four scales. No other main or interaction effects were found to be significant.

Figure 1
Sub-Sample Psychological Measure Trends



Relationship of Health Status and Anxiety and Fatigue

To assess the relationship between overall health status (ESCTOT) and the psychological measures, a linear regression was conducted using cross-sectional sample data. The four psychological measures were stepwise regressed on ESCTOT. As was found in Study One, tension/anxiety and fatigue were significantly correlated with an index of total health symptoms. SAM-F did not add significantly to the explained variance when added last to the equation. Table 10 presents the specific results of this analysis.

Table 10

Stepwise Regression of Psychological Measures on ESCTOT Cross-Sectional Sample (n = 518)

Predictor Variable	Cumulative Multiple R	Cumulative R^2	R^2 Change	Standardized Beta
POMS-Tension/Anxiety	.5519	.3046	.3046	.2724**
POMS-Fatigue	.5829	.3398	.0352	.2334**
State Anxiety	.5928	.3514	.0116	.1658*

*$p < .01$; **$p < .001$

Discussion

The protocol of the present study was designed to detect the impact of environmental stressors on human physical and psychological health and performance. Repeated measures were employed and specific watchstations were targeted for evaluation due to their particularly high exposure to stressors of interest. However, as noted previously, conditions of high heat, humidity, imminent danger, and periods of extended GQ had lessened considerably at the time of study implementation. A potentially extremely inhospitable environment had moderated to what could more aptly be characterized as an "unpleasant" environment. The results presented in this report serve primarily to expand a database of operating forces health and psychological measures, and to support and extend the findings from Study One.

WBGT Index

When evaluated against the PHEL curves, WBGT Index values at all Engineering and Topside watchstations warranted sound preventive measures against thermal stress. Given the WBGT Index values obtained, it was not infrequently the case that normal engineering watch durations of four hours were in excess of exposure limits specified by the PHEL curves. Although the long-term effects of repetitive exposure to heat stress have not been fully identified, resultant problems with thermal strain are likely to be exacerbated by sleep/wake cycle disruptions and fatigue.

Sleep and Fatigue

Clearly, inadequate and poor quality sleep remain problematic under wartime cruising conditions. In this respect, the sleep questionnaire findings from the present study validated the findings from Study One. Although the grand mean for POMS-F from the current cross-sectional sample was significantly less than that of Study One ($\underline{t}[799] = 2.76$, $\underline{p} < .01$; $\underline{M}$ Study One = 11.0, $\underline{M}$ Current Study = 9.7), neither mean was significantly different from a normative sample of college men (McNair et al., 1971). It was found that MSO crews reported significantly greater POMS-F scores than crews aboard the other three ship classes surveyed. This was probably due to the exceptionally long workday and the higher topside activity level aboard the MSOs required by continuous mine-sweeping operations.

The literature is extensive regarding the SAM-F scale and military samples. Based on this literature, general statements regarding absolute levels of fatigue are possible. In general, SAM-F scores of 12 or greater indicate alertness; 11 to 8, moderate fatigue; and 7 or less, severe fatigue (Storm, 1980). A breakdown of the cross-sectional sample into the above three fatigue categories revealed that 36.7% of the subjects were experiencing severe fatigue (i.e., scored 7 or less on the SAM-F scale) at the time of questionnaire administration. Under such conditions, imposition of additional sleep loss due to extended GQ or other stressors can potentially lead to degradations in performance. Conservation of individual resources during Condition III cruising is of the utmost importance to maximize crew capabilities should prolonged GQ be required.

With regard to sub-sample subjects, a significant post-watch increase in SAM-F was found. However, for these subjects, absolute fatigue levels were not experienced as severe. The POMS-F measure was sensitive to a decrease in subjective fatigue over the three testing days for the sub-sample subjects. This decrease is difficult to explain. Such an effect may have been due to some factor from the research itself (e.g., Hawthorne effect, schedule shift) or possibly desensitization to the research survey questions as a consequence of multiple repeated measures. This issue needs further attention in future field studies. Although an explanation of rapid adaptation to continuous operations is attractive, prior to the study, crews aboard all the ships had been involved in continuous operations of the same type evaluated for periods considerably in excess of the total period examined. Hence, rapid fatigue adaptation does not explain the sub-sample decrease over several days.

Health Symptoms

Despite moderately large percentages of subjects reporting the presence of several negative health symptoms, it must be emphasized that severity was relatively slight across all health symptom composites. Consistent with task demands and extant environmental conditions, Mental Fatigue, Heat Distress, and Muscle Fatigue were the most frequently reported symptoms. CG and LPD crews, overall, reported greater Heat Distress and Muscle Fatigue than crews aboard the MSOs and the FFG. This was probably due to hotter internal ship environments with somewhat less adequate cooling ventilation. Moreover, personnel aboard the smaller ships, particularly the MSOs had greater access topside.

Tension/Anxiety

Overall, tension/anxiety levels of the cross-sectional sample appeared to be within normal limits. However, junior enlisted personnel (E1 to E3) reported greater subjective tension/anxiety than higher paygrade personnel. This result may have been a reflection of the relative inexperience of these sailors in extended at-sea operations and the potentially hostile environment. This result notwithstanding, the POMS-TA grand mean from the present study was significantly lower than that from Study One and from that of a college male sample (McNair et al., 1971). To the extent tension/anxiety scores were related to probable danger, the difference between the present study and Study One was not surprising -- the threat of hostilities was extreme during Study One; a cease-fire was in effect during the present study. Although hostilities could have broken out at any time, the primary active threat during this study was the danger of accidentally striking a submerged mine. The finding that POMS-TA scores for college males were higher than sailors in this study is interesting and difficult to explain. Perhaps the normative sample of college males used for the POMS-TA had different item-response characteristics or possibly somewhat elevated levels of tension/anxiety. (Table 11 provides comparisons between the cross-sectional sample, Study One, and other samples.)

As can be seen in Table 11, the cross-sectional sample SA scale mean was significantly greater than the means of a sample of male college students and a sample of male government employees (Spielberger et al., 1983); it was significantly less, however, than that of a sample of male military recruits (Spielberger et al., 1983). The SA scale was not administered in Study One, therefore, comparisons of results with that study were not possible.

Table 11

Cross-Sectional Sample Tension/Anxiety Comparisons with Normative Samples

POMS-TENSION/ANXIETY[a]

Current Sample (N=535)	Study One (N=265)	College Males (N=340)
M (SD)	M (SD)	M (SD)
10.5 (6.9)	12.4 (5.9)***	12.9 (6.8)***

STATE ANXIETY[b]

Current Sample (N=535)	Age 19-39 Male Gov't Workers (N=446)	College Males (N=296)	Male Military Recruits (N=1893)
M (SD)	M (SD)	M (SD)	M (SD)
40.9 (11.2)	36.5 (9.8)***	36.5 (10.0)***	44.1 (12.2)***

[a] POMS-TA college male sample from (Mcnair, Lorr, & Droppleman, 1971).

[b] State Anxiety comparative samples from Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983).

*** t-test comparison with current study cross-sectional sample, $p < .001$.

The baseline tension/anxiety scores of sub-sample subjects were significantly less than those of the cross-sectional sample. In addition, the results of repeated measures revealed a trend of decreasing tension/anxiety over the course of several days of measures. These results, similar to those found with the fatigue scales, are difficult to interpret but may have been due to artifacts in the research methodology from such sources as selection bias, desensitization, or a Hawthorne effect.

Health Status and Psychological States

The relationship between an index of total health symptoms, ESCTOT, and the subjective psychological measures replicated the results found in Study One. Tension/anxiety and fatigue scales accounted for 34% of the variance in ESCTOT. Although there is research to suggest that anxiety is a risk factor for health (Davis, Morrill, Fawcett, Upton, Bondy, & Spiro, 1962) and injuries (Palinkas & Coben, 1987) and that sleep loss and fatigue are related to poor judgement and increased accidents (Colquhoun, 1972), the relationship between health status and tension/anxiety, fatigue, and various other mood states is likely to be a reciprocally interacting one; environmental stressors, of course, serving as primary exogenous determinants.

Conclusion

The literature is replete with facts documenting the limits of human performance when impinged upon by individual stressors (see Hockey, 1983, for comprehensive coverage). Of great interest in the present study was capitalizing on the opportunity for identifying effects resulting from the interaction of multiple stressors. However, moderating climatic conditions, reduced regional hostilities, and the virtual elimination of GQ requirements substantially decreased the likelihood of finding health and psychological ill-effects consequential to both individual and combined stressors. In large part, the results provided in the present report validated the findings from Study One by obtaining similar profiles of cross-sectional sleep problems and health symptoms associated with Condition III operations Self-report health symptoms were relatively minor in severity and appeared to be commensurate with the unpleasant but not extreme environmental conditions during the study period. The contribution of the present report was to describe health status, anxiety, and fatigue during wartime cruising conditions in a moderately high heat environment. In that regard, the findings represent a point of departure for further at-sea studies to be undertaken during more extreme climatic conditions. Complete reports on physiological effects and cognitive performance during the study partially described in the present report will be forthcoming.

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Appendix A

Physiological Heat Exposure Limit (PHEL) Curves[a]

3-13 MANUAL OF NAVAL PREVENTIVE MEDICINE 3-14

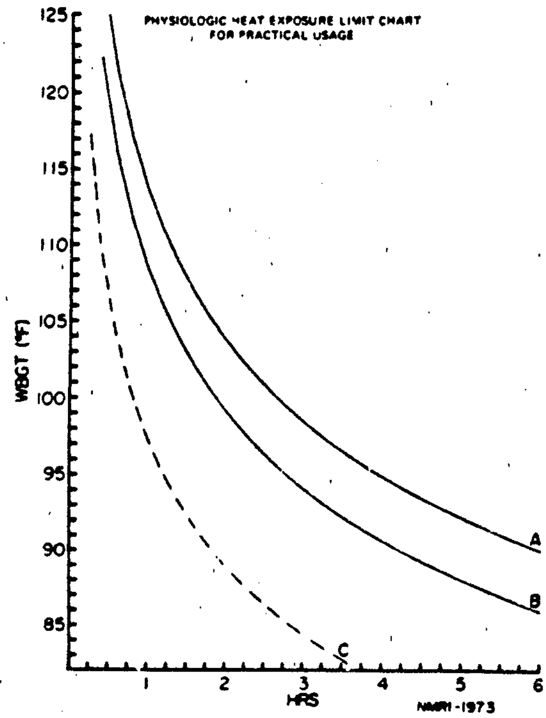

Figure 3-6.

Table 3-9. Examples of Duties Corresponding to Metabolic Rates of Respective PHEL Curves

PHEL Curves (t_{wm} Metabolic Rates)	Duties*
"A" (152 Kcal/hr)	*Water Level Checkman* during other than heavy repair or casualty control activity.
"B" (192 Kcal/hr)	*Burnerman* during other than heavy repair or casualty control functions; *Messenger* during other than full power conditions or when continuous mobility is not required.
"C" (252 Kcal/hr)	*Messenger* during full power operation or other activities requiring continuous mobility; any personnel involved in heavy repair work requiring manual labor (e.g., pump disassembly); casualty control functions; laundry/scullery work assignments.

*These duties are comparable with those assignments found aboard steam propulsion plant ships rated at 600 and 1200 pounds per square inch.

[a]Reproduced from NAVMED P-5010-3, 1974

Appendix B

Sleep Questionnaire Items and Cross-Sectional Sample Response Percentages[a]

1. When you are working or need to stay awake, do you ever fall asleep even though you are trying hard to stay awake?
   - 52.1% 1. never or almost never
   - 38.2% 2. sometimes
   - 6.9% 3. often
   - 2.8% 4. always or almost always

2. Do you ever have trouble falling asleep?
   - 21.8% 1. never or almost never
   - 56.5% 2. sometimes
   - 15.8% 3. often
   - 6.0% 4. always or almost always

3. If you have trouble falling asleep, how often does this happen?
   - 1.0% 1. less than once a year
   - 7.4% 2. less than once a month
   - 13.9% 3. about once a month
   - 44.4% 4. 1 or 2 times per week
   - 22.5% 5. 3 or 4 times per week
   - 9.1% 6. 5 or more times per week
   - 1.7% 7. does not apply to me

4. If you have trouble falling asleep, what is it that keeps you awake?
   - 64.4% 1. thoughts running through my mind
   - .7% 2. aches and pains
   - 13.8% 3. too much noise
   - 17.5% 4. other
   - 3.4% 5. does not apply to me

5. Do you usually feel well-rested after you wake up and first get out of bed?
   - 8.6% 1. always or almost always
   - 15.0% 2. often
   - 47.7% 3. sometimes
   - 28.6% 4. never or almost never

6. Which choice below best describes how you usually feel for the first 2 or 3 hours after you wake up from your normal sleep period on workdays?
   - 13.0% 1. alert, wide awake
   - 22.4% 2. high level, but not at peak
   - 23.1% 3. awake, but relaxed
   - 15.9% 4. a little foggy, let down
   - 22.0% 5. slowed down, sleepy
   - 3.4% 6. fighting sleep
   - .2% 7. almost asleep

[a]Rounding may result in item total percentages not equal to 100%.

Appendix C

Environmental Symptom Composite Items

Mental Fatigue:	- I have trouble concentrating. - I have trouble remembering. - I feel worried about something. - I feel irritable. - I feel tired. - I feel sleepy. - I had trouble sleeping last night.
Heat Distress:	- I am sweating. - My hands are sweaty. - I feel warm.
Muscle Fatigue:	- I feel weak. - My muscles are tense. - My muscles ache.
Eye/Sight Problems:	- My eyes feel irritated. - My eyes are watery. - My vision is blurry.
Headache:	- I have a headache. - My head is throbbing. - I feel lightheaded. - I feel nauseous.
Ear/Hearing Problems:	- I have ringing in my ears. - My ears are blocked. - My ears ache. - I can't hear well.
Nasal Distress:	- My nose is blocked. - My nose is running.
Gastrointestinal Distress:	- I feel stomach pressure. - I have stomach pains. - My stomach is upset.
Coordination Problems:	- My sense of balance is off. - I feel clumsy.
Chills:	- My hands feel cold. - I feel chilly. - I am shivering.

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(U) SLEEP PROBLEMS, HEALTH SYMPTOMS, AND TENSION/ANXIETY AND FATIGUE DURING WARTIME CRUISING IN A MODERATELY HIGH HEAT/HUMIDITY NAVAL ENVIRONMENT

12 PERSONAL AUTHOR(S)
Timothy P. Steele, David A. Kobus, Guy R. Banta, and C. Glenn Armstrong

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This is the first report of a second study in a series designed to quantify cognitive, behavioral, and physiological responses to sustained operations in a hostile theater of operations under conditions of high heat and humidity. Findings are reported from self-report sleep, health symptoms, and psychological measures obtained during the months of September and October, 1988, in the Persian Gulf. A cross-sectional sample of officers and enlisted personnel (N=562) aboard nine U.S. Navy combatants was surveyed. A sub-sample (n=33) of Combat Information Center, Engineering, and Topside watchstanders was selected for repeated measures over four days and more extensive physiological and psychological testing. Problems with falling asleep, poor quality sleep, sleep inertia, and sleeping on the job were found to affect, in general, approximately a quarter of the subjects surveyed. Nearly 37% of all personnel surveyed indicated severe fatigue on a subjective fatigue checklist. Mental Fatigue, Heat Distress, and Muscle Fatigue were the most frequently reported environmental health symptoms; however, the severity of such symptoms was relatively minor. CG and LPD crews reported greater Heat Distress and Muscle Fatigue than crews aboard MSOs and an FFG.

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19. Overall, tension/anxiety levels of the cross-sectional sample appeared to be within normal limits. Junior enlisted personnel, however, reported greater tension/anxiety than higher paygrade personnel. Repeated measures of sub-sample subjects' tension/anxiety and fatigue showed a decreasing trend over a three day test period. The relationship between tension/anxiety and fatigue measures and an index of total health symptoms was significant ($R = .59$). The present findings provide a point of departure for further at-sea studies to be undertaken during more extreme climatic conditions. Reports on physiological effects and cognitive performance will be forthcoming.