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A COMPARATIVE ANALYSIS BETWEEN THE NAVY STANDARD WORKWEEK AND THE WORK/REST PATTERNS OF SAILORS ABOARD U.S. NAVY CRUISERS

by

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September 2009

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In March 2008, two U.S. Navy ships failed their Inspection and Survey (INSURV) assessments with deficiencies ranging from inoperable equipment to inadequate housekeeping practices. The question of why these problems exist must be addressed. A study to determine the total number of hours Sailors actually work in contrast with the Navy Standard Workweek Model is extremely important. Previous research regarding this topic has indicated that the Navy Standard Workweek does not accurately reflect the daily activities of Sailors. In fact, results from a recent study on USS CHUNG HOON by Haynes, showed that a majority of the Sailors received much less sleep and worked longer hours than allocated in the Navy Standard Workweek Model. This research focuses on widening the scope from the Haynes study on U.S. Navy destroyers, to determine if similar conditions exist onboard U.S. Navy cruiser vessels. The results indicated that 85% of the participants within the study exceeded the 81 hours of available time allotted by the Standard Navy Workweek. On average, Sailors in the current study, excluding officers, worked 9.90 hours per week more than allotted in the Navy Standard Workweek.

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In March 2008, two U.S. Navy ships failed their Inspection and Survey (INSURV) assessments with deficiencies ranging from inoperable equipment to inadequate housekeeping practices. The question of why these problems exist must be addressed. A study to determine the total number of hours Sailors actually work in contrast with the Navy Standard Workweek Model is extremely important. Previous research regarding this topic has indicated that the Navy Standard Workweek does not accurately reflect the daily activities of Sailors. In fact, results from a recent study on USS CHUNG HOON by Haynes, showed that a majority of the Sailors received much less sleep and worked longer hours than allocated in the Navy Standard Workweek Model. This research focuses on widening the scope from the Haynes study on U.S. Navy destroyers, to determine if similar conditions exist onboard U.S. Navy cruiser vessels. The results indicated that 85% of the participants within the study exceeded the 81 hours of available time allotted by the Standard Navy Workweek. On average, Sailors in the current study, excluding officers, worked 9.90 hours per week more than allotted in the Navy Standard Workweek.

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EXECUTIVE SUMMARY

The primary method to determine manning aboard ships of the United States Navy is the Office of the Chief of Naval Operations (OPNAV) Instruction 1000.16K Navy Total Force Manpower Policies and Procedures. Appendix C of that document states that the 168 hours in the Navy Standard Workweek (NSWW) are divided into two categories: Available time (81 hours) and Non-Available time (87 hours). Available time consists of tasks required to be performed by each Sailor and include watch-standing, maintenance duties, training, and attendance of daily and/or impromptu meetings (i.e., service diversion). Non-available time consists of all personal time that is allotted (e.g., messing, sleeping, and free time).

This thesis poses three questions: (1) Has the U.S. Navy underestimated the number of hours each Sailor works each week onboard U.S. Navy cruisers? (2) What are the work/rest patterns of U.S. Navy cruiser Sailors, and do their departments differ in terms of the work they conduct? (3) Finally, should the U.S. Navy Standard Workweek be revised to more accurately reflect requirements of Sailors in various departments throughout the ship?

To address these questions, Sailors onboard USS LAKE ERIE (CG-70) and USS PORT ROYAL (CG-73) wore wrist activity monitors (WAMs) for 24 days and completed surveys that detailed their daily activities. These data were then compared to the Navy Standard Workweek to determine if the NSWW model correctly reflects the daily activities of cruiser vessel Sailors. The actigraphy data collected by the WAMs were analyzed using the Fatigue Avoidance Scheduling Tool (FAST), which uses the Sleep, Activity, Fatigue and Task Effectiveness (SAFTE) model to predict individual effectiveness.

In a previous study conducted by Nguyen (2002), the effects of reversing the work-sleep schedules of the crew aboard USS JOHN C. STENNIS were explored. The study also reviewed current research in the field of sleep

deprivation and the resultant performance decrements in humans. The results of the study indicated that a significant number of sailors had difficulty adjusting to working nights and sleeping days, commonly referred to as shiftwork.

Additionally, the Nguyen study found that individuals working topside (e.g., flight-deck/ bridge watch standers) had greater difficulty adjusting to the reversed shiftwork schedule than their counterparts who worked below decks (e.g., engineering personnel not accustomed to seeing daylight). Using a validated model of human performance and fatigue, Nguyen demonstrated that the level of fatigue and sleep deprivation observed in the study population significantly reduced individual effectiveness.

In a related study, Haynes researched whether the amount of work and rest provided to Sailors during a typical pre-deployment cycle accurately depicted the Navy Standard Workweek model. Results confirmed that a majority of the Sailors (n = 21) received much less sleep and worked longer hours than allocated in the NSWW OPNAVINST Model. In fact, for Sailors participating in that study, eighty-five percent exceeded the 81 hours of Available time allotted by the Standard Navy Workweek. On average, the Sailors worked 16.95 hours per week more than they were allotted in the Navy Standard Workweek which equated to 2.4 hours more per day in Available time.

Based on this information, this research was designed to widen the scope of the Haynes study on U.S. Navy destroyers to determine if similar conditions exist onboard U.S. Navy cruiser vessels. Additionally, this thesis discusses the relationships between sleep deprivation, crew performance, circadian rhythms, and the use of the FAST model to predict the effectiveness levels of each participant. Finally, this thesis evaluates whether proper manning levels are present, drawing on the analyses produced from the FAST assessment.

On average, senior personnel, both officer and enlisted, slept approximately 2 hours less than allotted by the Navy Standard Workweek. Senior Chief Petty Officers and Chief Petty Officers (both enlisted-ranked E-8/7 participants) averaged 6.26 hours of sleep, while senior Officers (Lieutenant Commanders [O-4] and above), averaged 6.38 hours of sleep per day. In contrast, junior personnel (enlisted ranks E-1 through E-3 and officer ranks W-2 through O-3) averaged 7.83 and 7.06 hours of sleep, respectively.

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I. INTRODUCTION

A. BACKGROUND

Sleep deprivation and stressful situations are nothing new to today's high-operation tempo Navy ships and their personnel. While the Navy has established measures to account for and mitigate hazards associated with fatigue and performance, "Standard Workweek" modeling is used solely to account for physical fatigue. According to Dawson and McCulloch (2005), "Fatigue has increasingly been viewed by society as a safety hazard"…and, "Despite the frequent use of prescriptive rule sets, there is an emerging consensus that they are [an] ineffective hazard control, based on poor scientific defensibility and lack of operational flexibility." In their writings, they later explain that many prescriptive "hours of service" (HOS) rules are derived from earlier regulatory models for managing physical fatigue rather than mental fatigue. Therefore, as an organization that operates in flexible, indeterminate conditions, the U.S. Navy Standard Workweek (NSWW) should consider adoption of alternative approaches to improve operational flexibility, performance, and safety.

These alternative approaches should take into account that the human body goes through a 24-hour cycle of biological processes, called the *circadian rhythm.* Circadian rhythms are controlled by the human biological clock (Dement, 1999). Previous studies conducted regarding circadian rhythms have shown that sailors who normally work during the daytime will show signs of reduced alertness when their schedule shifts and they work throughout the night (Carrier & Monk, 2000; Belenky et al., 1987). This resulting change to sleep during the day results in a sleep period that is not as restorative since the body is naturally fighting to stay awake and maintain alertness. Additional findings revealed that sleeping during the daytime also resulted in much shorter sessions of the required third, fourth, and REM stages of sleep (Eastman & Martin, 1999; VanCauter & Buxton, 2000). This break in routine leaves a person feeling fatigued and tired, despite sleeping for 6-to-8 hours.

Ideally, Sailors should have ample opportunity to get the 56 hours allotted to weekly sleep, as required by the U.S. Navy NSWW. Combating fatigue in Sailors is a critical determinant of the U.S. Navy's ability to effectively perform required missions and various evolutions (Haynes, 2007). While many of the tasks (e.g., continuous operations including watch-standing) occur at night, many Sailors operate on a watch rotation that significantly varies the time at which sleep can be obtained, often contributing to severe disruption of the circadian cycle.

The Office of the Chief of Naval Operations Instruction (OPNAV) 1000.16K outlines the “Navy Total Force Manpower Policies and Procedures.” In order to determine the personnel assigned to each class of ship, the Navy has designed a standardized version of one week of work performed while at sea. This work week is referred to as the Navy Standard Workweek (NSWW). Aggregating the total number of hours of a seven day work week, the Navy Standard Workweek allows 81 hours for “Available” time. Available time includes administrative work or maintenance, watch-standing, training and meetings. The remaining 87 hours (totaling 168 hours within a week) are provided to the sailor for sleeping, messing and personal free time and are called “Non-Available” time. “Available” refers to time available for Navy work activities.

Anytime a ship is considered underway (neither at-anchor nor alongside the pier), watches are manned according to one of three conditions of readiness. Afloat combatant platforms are expected to be capable of performing all assigned primary mission areas simultaneously while maintaining readiness Conditions I, II, and III (wartime/forward deployment cruising readiness) (Title X of the United States Code, Subtitle C, Part 1, Chapter 507, Article 5062; Miller & Firehammer, 2007). For this reason, the workweek for at-sea units is calculated based on wartime sailing and Condition III watch-standing.

Condition I watch-standing is established while the ship is at General Quarters, at which time maximum readiness and all watch-stations are manned. Navy guidelines (Title X of the United States Code, Subtitle C, Part 1, Chapter

507, Article 5062) state that this condition should be sustainable for a minimum of 24 hours. Conversely, Condition III watch-standing is normal wartime steaming, during which time the ship should be able to conduct warfare against any threat. The maximum expected crew endurance is 60 days, with an opportunity for 8 hours of rest provided per man per day. In Condition III, all essential watch-stations required for safe navigation, along with several additional watch-stations, are manned.

According to the U.S. Navy's official homepage (http://www.news.navy.mil/search/display.asp?story_id=24904), the "Rim of the Pacific" exercise. or RIMPAC for short, is considered the world's largest biennial maritime exercise, bringing together military forces from numerous countries (i.e., Australia, Republic of Korea, Canada, Chile, Peru, Japan, the United Kingdom, and the United States) in support of maintaining peace, security, and stability within the Pacific region. Throughout the exercise, numerous forces operate in coalition to conduct live missile, torpedo, and gunnery fire exercises. Crews are assessed on their ability to provide coverage for air defense, surface warfare, undersea warfare, maritime boardings, mine warfare, and anti-submarine warfare, while engaged within simulated tactical scenarios, providing each force and warfare commander the opportunity to train together and build positive relationships among allied nations.

This study offers a glimpse into the work week of Sailors of various ranks and qualifications onboard USS PORT ROYAL (CG 73) and USS LAKE ERIE (CG 70) during RIMPAC Exercise 2008 while in readiness Condition III. The purpose of this research was two-fold: 1) to determine the amount of work and rest provided to Sailors during a typical training exercise, and 2) to determine if the Navy Standard Workweek accurately reflects the activities of U.S. Sailors onboard U.S. Navy cruisers. In addition, this thesis discusses the relationships between sleep deprivation, crew performance, circadian rhythms, and the use of the FAST model to predict the effectiveness levels of each participant.

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II. LITERATURE REVIEW

A. FATIGUE

According to Battelle (1998), there is a consistent body of research that demonstrates that most people require an average of 8 hours of sleep per night to achieve normal levels of alertness without drowsiness throughout daytime hours, and to avoid the buildup of sleep debt. In addition, supplementary literature on the subject of fatigue has identified a number of symptoms that indicate the presence of fatigue, including: increased anxiety, decreased short-term memory, slowed reaction time, decreased work efficiency, reduced motivational drive, decreased vigilance, increased variability in work performance, increased errors of omission which increase to commission when time pressure is added to the task, and increased lapse with increasing fatigue in both number and duration (Dinges et al., 1997; Akerstedt & Folkard, 1997; Balkin & McBride, 2005). Although taking caffeine or prescribed medication can temporarily extend the performance of crews under unusual circumstances, it must be noted, the absence of sleep reduces crew efficiency and contributes to hazardous working conditions and fatigue (Performance Maintenance Guide, 2000; Van Dongen et al., 2001; Caldwell, 2005). The term “fatigue” has yet to be defined in a concrete fashion (Battelle Memorial Institute, 1998). However, human performance literature characterizes fatigue as “the deterioration in human performance arising as a consequence of several potential factors, including sleepiness.” Consequently, the Battelle report suggests that the term fatigue should be treated as a concept rather than an objectively-defined state of being.

In fact, the Battelle report suggests that tasks that require primarily physical performance are relatively immune to the effects of sleep loss. It has been well established that sleep loss does not impair the capacity for physical endurance to any measurable extent (Martin, Bender, and Chen, 1986).

McMurray and Brown (1984) noted that the only effect of sleep loss on physical capability is the subsequent need for a slightly longer recuperative period following physical exertion. It can be inferred from their work that mental exertion requires an even longer recuperation period than physical exertion.

Subsequently, Belenky et al. (1987) proposed that the relationship between sleep loss and performance decrements on various cognitive tasks are a result of three distinct mechanisms: (a) by causing brief "lapses" in EEG defined wakefulness (microsleeps of 1–10 seconds' duration); (b) by causing a steady state of reduced arousal during EEG defined wakefulness (i.e., between "lapses") that is manifested by a reduced capacity for sustained selective attention; and (c) by lowering mood and motivation levels, thereby reducing morale and initiative. They further state that each of these mechanisms includes factors that differentially contribute to impaired performance on all tasks during sleep loss; however, the degree to which each of these mechanisms affect performance depends upon the nature of the task.

Given that "sleepiness" or fatigue causes increased eye blinks, longer eye closure durations, and brief bursts of sleep called "microsleep," it is understandable that tasks that depend upon visual input are particularly sensitive to sleep disruption (Wickens et al., 2004). Understanding this, it is crucial that rating specialties such as Operations Specialists (OS), Fire Control Technicians (FC), and Sonar Technicians (ST) operate at maximum performance in all instances that require their full attention.

B. SLEEP

"The human need for sleep is a physiologically driven event that dominates our daily activities and is central to our ability to perform both physical and cognitive tasks" (Miller & Firehammer, 2007, p.6). The Center for Operational Performance Enhancement (COPE) categorizes sleep into periods or stages: Non-Rapid Eye Movement (NREM) stages One through Four, and a single period of Rapid Eye Movement (REM) sleep.

The first stage of NREM sleep is experienced when drifting in and out of sleep. During Stage One sleep, a person remains partially aware of the environment and sleep begins with lower voltage electroencephalogram (EEG) patterns. The second stage of NREM sleep is characterized by slowing of brain waves and begins the process of slow wave sleep or SWS. Marked by high amplitude slow waves on the EEG, Stage Three of NREM sleep is distinguished by the onset of "Delta" waves, or extremely slow brain waves. The first slow wave sleep epoch typically lasts about 15-20 minutes and the EEG patterns become progressively faster and lower in amplitude until a state that resembles an awake EEG is observed. Stage Three of sleep consists of approximately 20% –50% delta wave brain activity, and signals the beginning of deep sleep. The fourth and final stage of NREM sleep consists mostly (greater than 50%) of delta wave activity (Cohen, 1979). During these SWS epochs, it is difficult for the brain to switch from slow wave activity to the low amplitude/high frequency activity of wakefulness. Hence, transitioning from deep sleep to alertness is often accompanied by mental sluggishness or “sleep inertia.”

In Stages Three and Four of NREM, it is often difficult to awaken the sleeper. During REM sleep, muscle tone is lost and an active period of dreaming (paradoxical sleep) occurs. After approximately ten minutes of initial REM sleep, the brain cycles back to SWS over the next 60 minutes. Over the course of an 8-hour sleep period, the brain has approximately 90-minute cycles between Stages Two through REM, with more REM occurring in the latter half of an 8-hour sleep period (Fatigue Management Guide, 2005).

C. CIRCADIAN RHYTHM

Much like the physiological cycling events of sleep, the human body goes through a 24-hour cycle of biological processes called the *circadian rhythm,* which is controlled by the human biological clock (Dement, 1999). Previous studies conducted regarding circadian rhythms have shown that Sailors who normally work during the daytime will show signs of reduced alertness when their schedule shifts and they work through the night. This resulting change to sleep during the day results in sleep that is not as restorative, since the body is naturally fighting to stay awake and maintain alertness. Findings revealed that sleeping during the daytime results in much shorter sessions of the required SWS and REM stages of sleep (Taylor et al., 1997). This break in routine leaves a person feeling fatigued and tired despite having slept for 6-to-8 hours.

Traditionally, exposure to daylight following a normal night's sleep resets the body's biological circadian clock, which typically results in physical and mental peaks (increases) throughout the day (Krueger, 1989). In general, alertness levels peak to approximately 100% between the hours of 0800–1200 and 1500–2100 with troughs in performance following those times. Alertness naturally declines between the hours of 2100–0600 and reaches their lowest point from 0100–0400. It is during this time period that personnel on watch are especially susceptible to lapses in attention, which may result in accidents and errors in judgment.

Circadian desynchronization occurs when internal rhythms are no longer in tune with external cues or each other (Achermann & Borbely, 2003). External factors such as light and darkness, sleep, nutrition/diet, and social activities all have a dramatic effect on the 24-hour cycle. Continuous operations and sleep deprivation force the body to adapt and, all too frequently, schedules do not leave adequate time for the human body to make this adaptation.

D. SHIFTWORK AND WATCH ROTATIONS

Shiftwork is a form of work scheduling in which workers succeed each other at the same work stations in shifts that can be organized in rotating, continuous patterns (i.e., production or service is not interrupted). A large body of research has suggested that shiftwork, particularly night-shift work, has adverse consequences for health, states of mental well-being, and increases in work stress (Rosa & Bonnet, 1993). In fact, one major consequence of shiftwork is a reduction in sleep and the desynchronization of biological rhythms. As stated by

Belenky et al. (1987), work/rest schedules must take into account the nature of the work, its interaction with others doing the work, rest/sleep time, how far away from the work station the rest/sleep stations are located, meal provisions, showering facilities, etc., and when and where in the 24-hour day these things occur.

Primarily, U.S. Navy sea going assets operate on a rapidly rotating shift system in which individuals perform their duties in a continuously rotating schedule. Typically working on a two, three, or in some cases four section watch rotation, Sailors quite often find themselves cycling through various watch stations daily only to repeat the cycle of watch scheduling once every 3 days. It can be inferred from previous research regarding shiftwork that continuously working inconsistent shifts interrupts the circadian rhythm and forces these individuals to remain in a fluctuating state of diurnal sleep and reentrainment of the circadian rhythm (Monk, 1986).

E. HUMAN PERFORMANCE MODELS OF FATIGUE

With the ever-increasing demand on military personnel throughout the world, human performance is required 24 hours per day, 7 days per week while conducting operations. In order to objectively measure performance decrements in military personnel who are subject to fatigue, the Sleep, Activity, Fatigue and Task Effectiveness (SAFTE) Model was developed by Walter Reed’s Army Institute of Research’s Dr. Steven R. Hursh, to predict performance decrements. SAFTE attempts to predict the cognitive effectiveness of an individual based on prior sleep episodes, and can also be used in an attempt to uncover potential problems with work/sleep schedules, allowing the planners to optimize personnel management. Figure 1 depicts 5 days of the typical circadian cycle utilizing the SAFTE model FAST (Fatigue Avoidance Scheduling Tool) program.

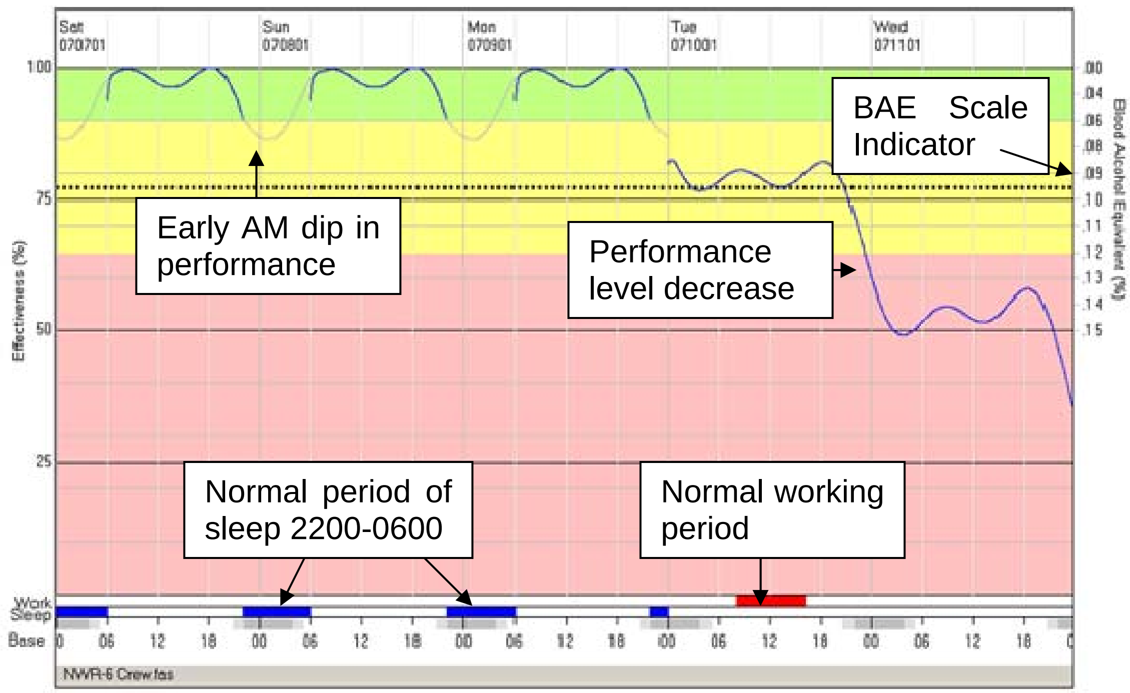

Figure 1. Typical Circadian Rhythm Cycle Depicted from FAST Software Analysis (From Warfighting Endurance Management-Air Force Counter Fatigue Guide, 2004)

The underlying model for SAFTE includes a sleep reservoir, circadian rhythm, and sleep inertia component that combines additively according to Hursh (March, 2004). Sleep times and duration are generated based on either real world data or an "auto sleep" algorithm. In this example, the only technical assumption is that sleep occurs between 22:00–06:00 hours. These times may be adjusted in the software interface to represent actual sleep schedules; however, the SAFTE Model does not include the effects of physical work, workload, or level of interest in task.

Subsequently, the SAFTE model has been applied to the construction of a Fatigue Avoidance Scheduling Tool (FAST), which is designed to help optimize the operational management of military personnel, but is not limited solely to this application. As reported, the software interface provides the user to schedule input and predictions in graphical and tabular form, parameter tables used for adjusting the model, and description boxes for schedules and events.

The SAFTE model by Hursh (2004) is seen in Figure 2, beginning with the sleep reservoir in the center at the bottom of the figure. This sleep reservoir is considered full when the individual is well rested, and begins to deplete as the individual is either awakened or remains active. When the individual sleeps, the sleep reservoir begins to replenish. The rate at which the sleep reservoir is refilled is a function of the intensity and quality of the individual's sleep. Sleep intensity is modeled as a function of the time of day and the current level of the sleep reservoir; hence, the quality of the sleep is governed by external influences. The result is the predicted measure of an individual's effectiveness. The SAFTE model has been tested, using empirically-derived data, with remarkable predictive accuracy. The SAFTE model produced an r^2 of 0.94 (i.e., 94% of the variation within the model can be accounted for or explained in relation to time and sleep).

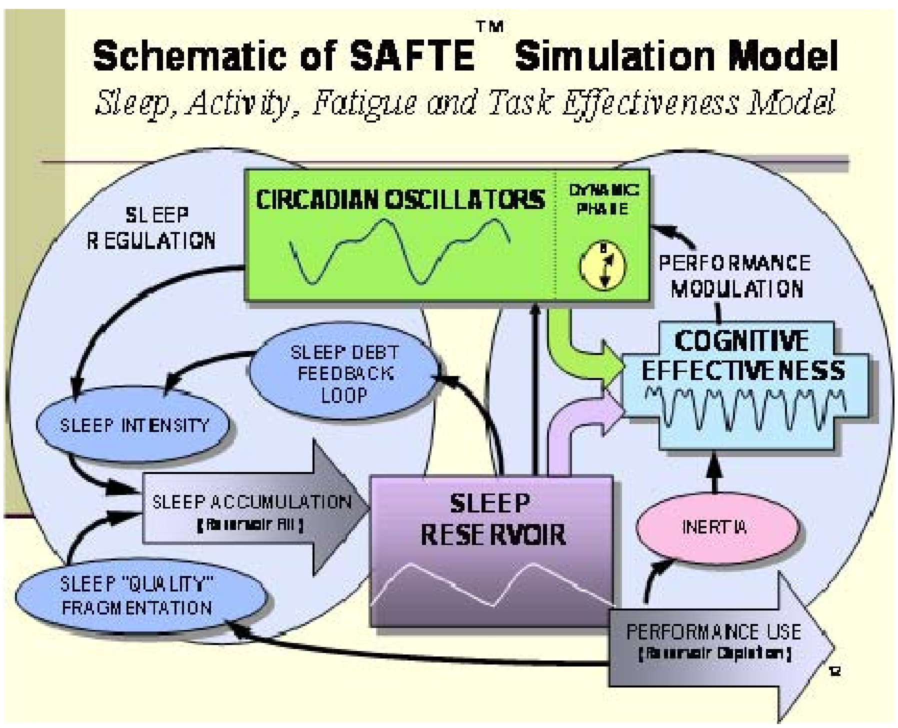

Figure 2. SAFTE Model (From Hursh et al., 2004)

The Fatigue Avoidance Scheduling Tool (FAST) uses the SAFTE Model to provide an estimate of the predicted effectiveness of an individual (Hursh, 2004). Over a period of time, FAST provides a graphical representation of the estimated fatigue level of an individual. FAST also provides a blood alcohol scale to equate the effects of fatigue on an individual, likening it to the effects of alcohol intoxication. A lapse index is also available that shows how likely an individual is to miss a critical piece of information. Actigraphy data from sleep watches worn by individuals can then be uploaded into FAST program to show the predicted level of effectiveness during a given time interval.

As seen in Figure 3, the FAST designated periods, in which the individual reported being on watch, are shaded in red blocks at the bottom of the figure. The left side of the FAST plot is the predicted effectiveness scale. The green horizontal band at the top represents the period of time when the individual is operating at a predicted effectiveness of 90% or better, and the yellow horizontal band represents the period of time when the individual is operating at a predicted effectiveness between 65% and 90%. The light red horizontal band represents predicted effectiveness below 65%. On the right side of the vertical scale, a Blood Alcohol Equivalence scale equates the effects of fatigue to alcohol intoxication.

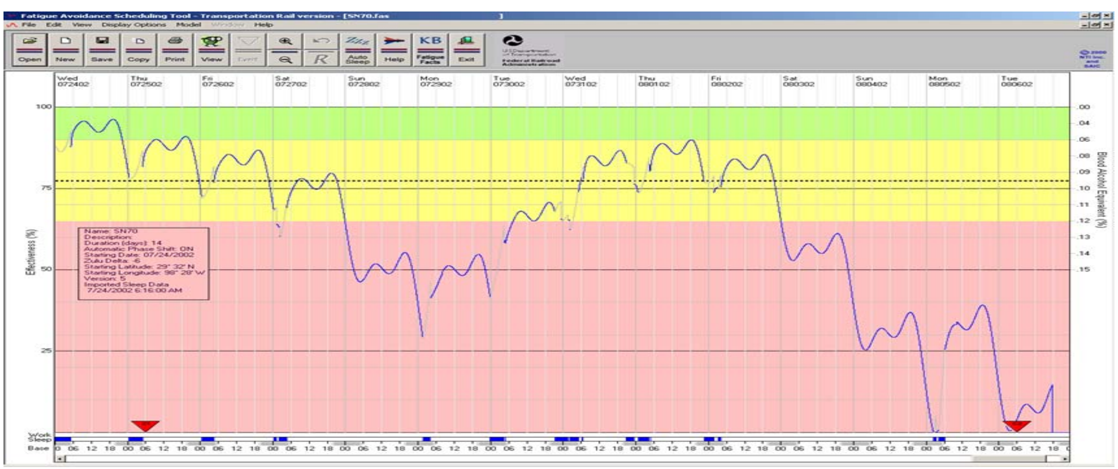

Figure 3. Fatigue Avoidance Scheduling Tool Plot (From Version 1.600T)

F. NAVY STANDARD WORKWEEK

The Navy Standard Workweek is the official guidance used by the U.S. Navy to determine the number of personnel required to man naval vessels (OPNAVIST 1000.16K). It is used by the Chief of Naval Operations to determine manpower requirements, and divides a standard seven-day week (168 hours) into two categories: Available Time and Non-Available Time. The amount of available time is calculated at 81 hours, with the remaining 87 hours in the week as non-available time. For "at sea" units, the workweek is based on expected wartime conditions, with units in Condition III steaming. In Condition III the expected endurance for each crew is 60 days, with 8 hours per day for rest per Sailor (see Table 1).

Condition I, watch-standing, is established while the ship is at General Quarters, at maximum readiness, and all watch-stations are manned. Navy guidelines state that this condition should be sustainable for a minimum of 24 hours. Conversely, Condition III watch-standing is normal wartime steaming, during which time the ship should be able to conduct warfare against any threat. The maximum expected crew endurance is 60 days, with an opportunity for 8 hours of rest provided per man per day. In Condition III, all essential watch-stations required for safe navigation, along with several additional watch-stations, are manned (Title X of the United States Code).

Readiness Conditions	Wartime/Forward deployed cruising readiness requirements
Condition I	Sailors are expected to perform for up to 24 hours continuously
Condition II	The maximum expected duration is 10 days, with a minimum of 4 to 6 hours of rest provided per man per day
Condition III	The maximum expected crew endurance is 60 days, with an opportunity for 8 hours of rest provided per man per day

Table 1. U.S. Navy Wartime Readiness Condition Chart (From United States Code, Title X.)

Table 2 is a detailed description of the Navy Standard Workweek for afloat wartime military personnel. Available time consists of standing watch, maintenance, training and meetings. Of the available time, watch-standing is allotted 56 hours per week per Sailor. Maintenance includes all required equipment upkeep and repair of the ship, and is allotted 14 hours per week per Sailor. Seven hours per Sailor per week is allotted for training, while 4 hours per week is allocated for meetings.

Navy Standard Workweek (OPNAVINST 1000.16K)	
Ship Standard Workweek	81 Hours
Productive Workweek(Note 1)	70 Hours
Total Hours Available Weekly	**168 Hours**
Less Non-Available Time:	
Sleeping	56 Hours
Messing	14 Hours
Personal Time	14 Hours
Sunday Free Time	3 Hours
Less:	
Training (Note 2)	7 Hours
Service Diversion (Note 3)	4 Hours
Total Hours Available for Productive Work (Note 1)	70 Hours
Note 1: For watchstanders, 56 hours is allocated to watch stations (8 hours X 7 days) (14 hours available for work in addition to 56 hours watch-standing = 70 hours)	
Note 2: Training is an activity of an instructional nature, which contributes directly to combat readiness and deducts from the individual's capability to do productive work. Training fours are factored to reflect those scheduled events (e.g., general drills, engineering casualty damage control) for all hands. Hours indicated have been standardized for Condition III in the Ship's Manning Documents.	
Note 3: Service diversion consists of actions required of military personnel regulations or the nature of shipboard/staff routine. Service diversion includes, but is not limited to, the following types of activities:	
1) Quarters, inspections, and sick call.	
2) Other administrative requirements including: Commanding Officers Non-Judicial Punishment (NJP), participation on boards and committees, interviews, and non-training-related assemblies.	
3) Flight and hangar deck integrity watches.	

Table 2. Detailed Description of Navy Standard Workweek for Afloat (Wartime) Military Personnel (From OPNAVINST 1000.16K—Appendix C)

Non-Available time consists of all other activities, and includes sleeping, messing, personal time, and Sunday free time. Each Sailor is allotted 56 hours per week for sleep and 14 hours for messing and personal time. The Navy Standard Workweek provides each Sailor with three additional hours of personal time on Sunday. While these guidelines are used to determine manning requirements, a fundamental question is whether the Navy Standard Workweek accurately reflects the activities of current USN Sailors.

This thesis poses three questions; (1) Has the U.S. Navy underestimated the number of hours each Sailor works each week onboard U.S. Navy cruisers? (2) What are the work/rest patterns of U.S. Navy cruiser Sailors and do their departments differ in terms of the work they conduct? and (3) Should the U.S. Navy Standard Workweek be revised to more accurately reflect requirements of Sailors in various departments throughout the ship?

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III. METHODOLOGY

A. PARTICIPANTS

For this study, participant volunteers were from two U.S. Navy ships: USS PORT ROYAL (CG 70), and USS LAKE ERIE (CG 73). Volunteers included Sailors standing various watch positions throughout the ship, although not every participant was assigned a watch-station. Each volunteer signed a participant consent form, a minimal risk consent statement, and a privacy act statement. A total of 83 Sailors volunteered to participate in this study; however, not all participants completed the required daily activity logs used to assist with the validation of analysis and findings. As a result, the data from only 39 of the participants were used for this current analysis. The jobs performed by participants varied according to their rating, rank and Navy Enlisted Classification Code (NEC) specialty. Additionally, the watch-stations manned by the Sailors encompassed Engineering, Combat Systems, Operations, Supply, and Administration departments.

B. IMPLEMENTATION AND DATA COLLECTION OF SLEEP DATA

1. Institutional Review Board

The study was submitted to the Institutional Review Board (IRB) at the Naval Postgraduate School to determine if participants were subjected to additional risk by entering the study. It was concluded that minimal-to-no-risk was involved in the study. Participants were briefed and then signed IRB forms. The IRB forms are included in Appendix A.

2. DATA COLLECTION

a. Sleep and Activity Logs

Each participant was given a self-reported sleep and activity log to complete during the underway period (see Figure 4). The log sheet divided a 24-hour day into fifteen-minute blocks. Each participant was required to log daily activities, to the nearest fifteen minutes, each day for 24 days, dividing the day into work or available time and non-work or non-available time. Each of these two main categories was then further divided. Available time was divided into: Watch, Maintenance/Admin, Training and Meetings. Non-Available time was also divided into: Sleep, Messing, Personal/Free time and Sunday Free time. The self-reported sleep and activity log data were used to determine how the Sailors were using their time.

Sleep Log

Actiwatch # ______________

Watch Station ________________________

Pencil or Pen Only

Fill in each block with the appropriate code

Date	0:00	0:15	0:30	0:45	1:00	1:15	1:30	1:45	2:00	2:15	2:30	2:45	3:00	3:15	3:30	3:45	4:00	4:15	4:30	4:45	5:00	5:15	5:30	5:45	6:00	6:15	6:30	6:45	7:00	7:15	7:30	7:45	8:00	8:15	8:30	8:45	9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	12:00	12:15	12:30	12:45	13:00	13:15	13:30	13:45	14:00	14:15	14:30	14:45	15:00
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Please use the following letters to indicate the activities for each day. Please indicate your activity to the nearest 15 minutes. For example, If you finish a task at 0810 fill in the block 8:15

Example	6:00	6:15	6:30	6:45	7:00	7:15	7:30	7:45	8:00	8:15	8:30	8:45	9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	12:00
	S	-	S	E	E	D	-	D	M	-	-	-	-	-	-	-	-	-	-	-	M	E	-	E	

LEGEND			
On Duty Activity		**Off Duty Activity**	
Maintenance/Work	M	Sleeping (including naps)	S
Training/Drills	T	Messing	E
Meetings/Quarters	D	Personal Time(TV, Reading)	P
Watch	W	Sunday Free Time	F

Figure 4. Example of Individual Participant Self-Reported Sleep and Activity Log (From Haynes, 2007)

b. Wrist Activity Monitors

Each participant wore a Wrist Activity Monitor (WAM) or sleep watch that recorded daily activity level for 24 days, starting on July 7, 2008 and ending on July 30, 2008. (See Figure 5, Wrist Activity Monitor [Actiwatch Minimitter Model AW/AW64].) The serial numbers of the participant's WAMs were used to match the WAM data with the survey data. Data collection packets of surveys and WAMs were assigned to each participant at 0800 June 30, 2008, and were collected upon return to port on August 4, 2008. The data were downloaded using Actiware 5.0 software. The data were then imported into FAST for further analysis. After importing the data into FAST, the data were compared to the completed survey to ensure that sailors were sleeping and working when they reported. Once the data had been compared to activity logs, predicted effectiveness levels were calculated using FAST for all Sailors.

Figure 5. Wrist Activity Monitor (Model AW)

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IV. RESULTS

A. DEMOGRAPHICS

Initially, 83 Sailors volunteered to participate in the study. Of those 83, 39 Sailors (37 men, 2 women) completed a Sleep and Activity Log and wore a wrist activity monitor (Actiwatch) for a period of at least one week. These 39 participants were chosen for further analyses. The average age of the participants was 29, with a standard deviation of seven years, two months. Rank varied relative to position of the participant's watch-station (E-1 through O-5).

Throughout the three-week underway period, several of the 39 participants sporadically documented their work/rest patterns for a 24-hour time period; however, each of the participants completed data entry from 0000 Sunday morning through 2359 Saturday night for at least a one week period. For instance, if a participant logged entries for the first 7 days and neglected to complete data entries for the remainder of the study, the data were still used for further analysis. Any logged data sets within a 24-hour period that did not complete the 24-hour cycle were omitted for purposes of the study.

The 39 Sailors with complete Sleep and Activity Logs were further separated into Officer (n = 6) and Enlisted (n = 33) categories (see Figures 6 and 7). Additionally, the 33 enlisted Sailors whose watch-stations or ratings were known were categorized into their respective departments. Due to the similarities of job task, Combat Systems and Operations departmental personnel were pooled from both ships and comprised 11 (Combat Systems) and 15 (Operations) Sailors, respectively. USS LAKE ERIE (CG-70) enlisted volunteer participants consisted of two Engineering department personnel, and three Supply department personnel in addition to the previously-mentioned Operation and Combat System department personnel. USS PORT ROYAL (CG-73) volunteers consisted of one participant from the Supply department and one participant from the Administrative department. Although six Officers were included in the overall study, it should be noted that the Navy Standard Workweek (NSWW) is only valid for the manning and placement of enlisted personnel onboard naval vessels.

Data were collected continuously over an entire underway period of 24 days at-sea (July 07–July 30, 2008). Data collected on the first and last day of the underway period were excluded due to incomplete data entries for the majority of participants. In addition, the first 3 days of analysis with the Fatigue Avoidance Scheduling Tool (FAST) were used for preconditioning. As noted in the Haynes (2007) study, FAST typically assumes that each Sailor received 8 hours of excellent sleep for the 3 days prior to the first recorded day. This 3-day period is known as pre-conditioning. If you use 3 days of actual sleep data for pre-conditioning, the model is more accurate, especially in chronic sleep deprivation conditions.

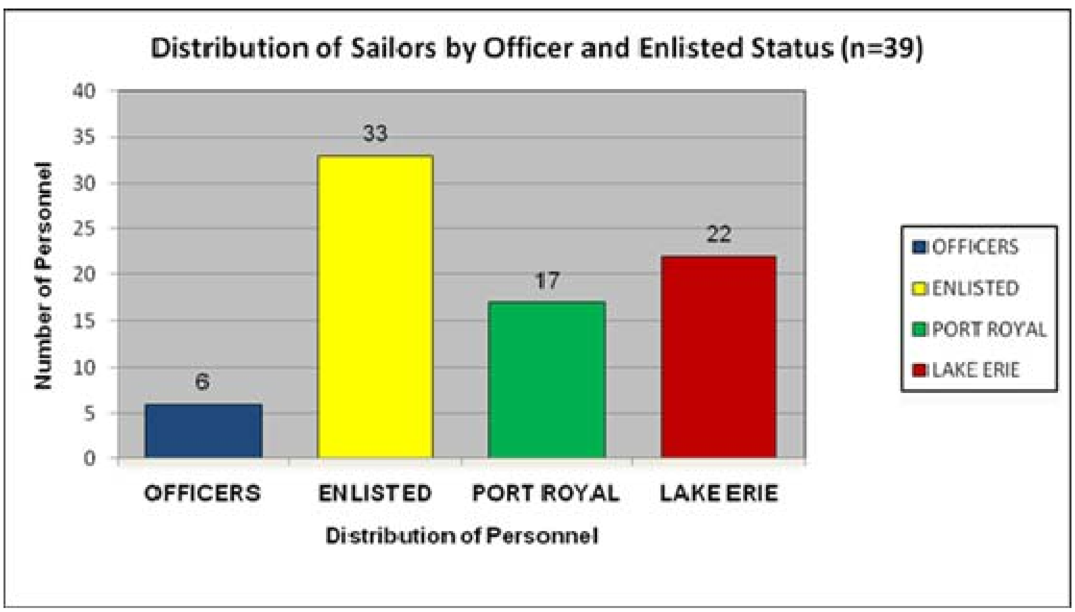


Figure 6. Distribution of Sailors for USS LAKE ERIE and USS PORT ROYAL

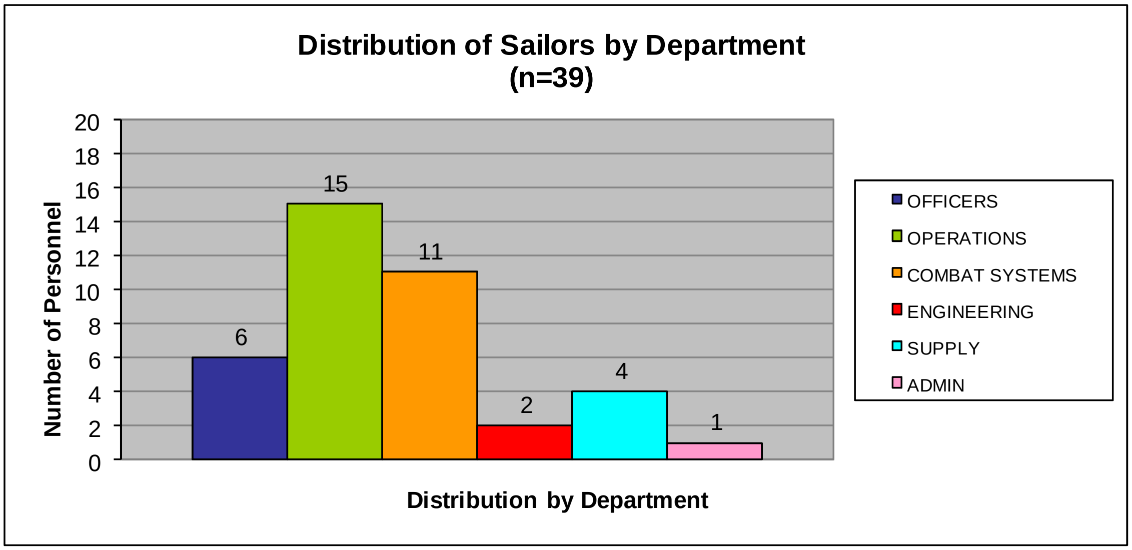


Figure 7. Distribution of Sailors by Officer and Enlisted Status

B. SLEEP AND ACTIVITY LOG RESULTS

Participants were asked to complete the Sleep and Activity Logs using 15 minute increments by indicating the Navy Standard Workweek category in which the individual was engaged. The data from the Sleep and Activity Logs were then used to determine the amount of time each Sailor spent in each category of the Navy Standard Workweek. Due to the number of Sailors reporting Sunday free time as personal time, these two categories were combined. This information was then compared to the requirements set forth in the Manual of Navy Total Force Manpower Policies and Procedures (OPNAVINST 1000.16K) in order to determine if the Navy Standard Workweek accurately reflected the actual Sailors' workweek.

The information in the Individual Sleep and Data Log Sheets was tallied, capturing each entry as a particular event. For instance, if a participant indicated that he/she slept between 7 and 9 hours and it could be verified from the activity wrist monitor results, that particular event was recorded as one entry under the seven-to-nine hour sleep category. With the 33 enlisted participants, a total of 663 events were logged over the three week period and distributed into the six distinct categories based upon their recorded entries and the department to which the personnel were assigned.

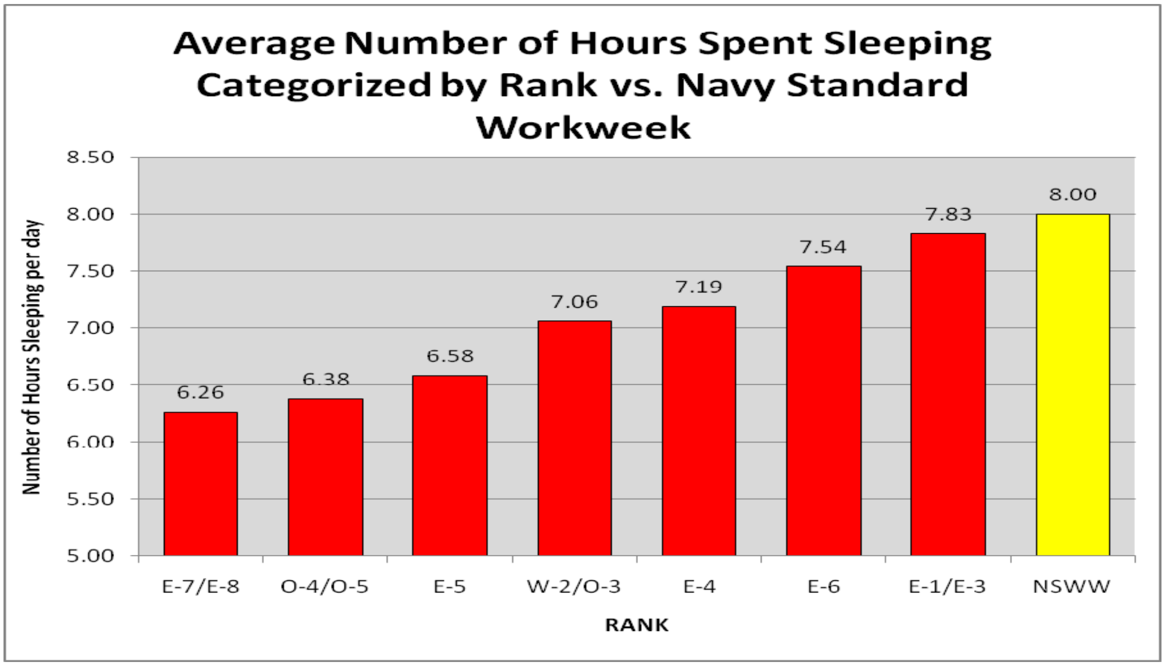


Figure 8. Recorded Number of Hours of Sleep by Rank

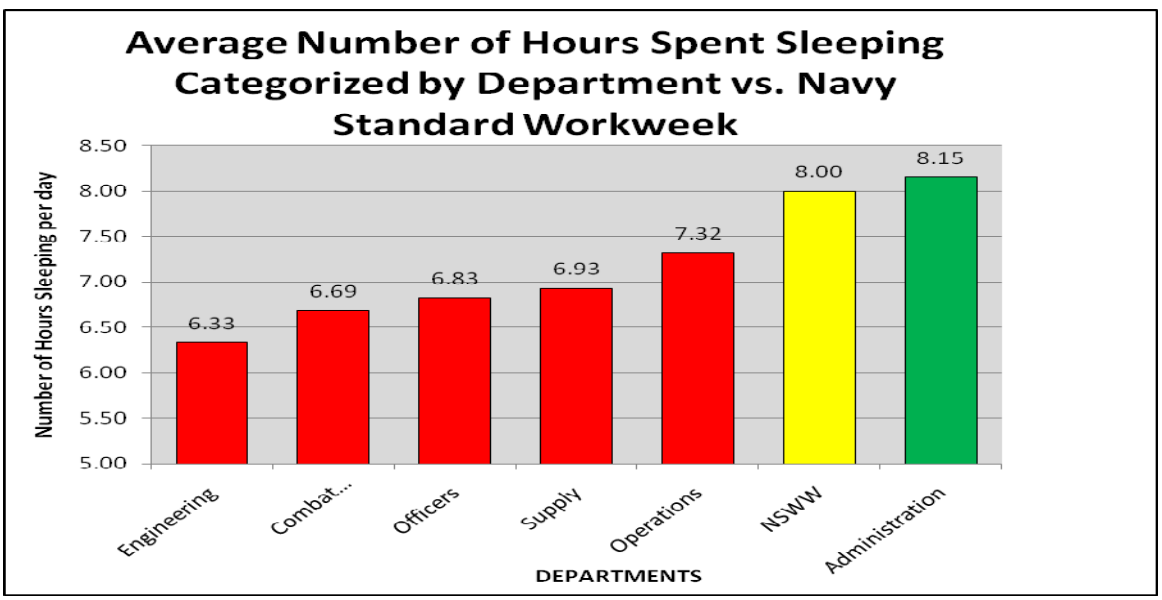


Figure 9. Recorded Number of Hours of Sleep by Department Regardless of Rank

On average, senior personnel, both officer and enlisted, slept approximately 2 hours less than allotted by the Navy Standard Workweek. Senior Chief Petty Officers and Chief Petty Officers (both E-8 and E-7 participants) averaged 6.26 hours of sleep, while senior Officers (Lieutenant Commanders and above), averaged 6.38 hours of sleep per day. In contrast, junior personnel (enlisted ranks E-1 through E-3 and officer ranks W-2 through O-3) averaged 7.83 and 7.06 hours of sleep respectively.

Overall analysis of the results indicated that 85% of the participants' "Available Time" exceeded the Standard Navy Workweek model of 81 hours per week throughout the entire underway period. In fact, only 5 participants (who were not actively engaged in the RIMPAC exercise) worked less than the allotted 81 hours. Three of those 5 participants were Cryptologic Technicians (one from USS PORT ROYAL and the other two from USS LAKE ERIE). Normally assigned to shore installations, Cryptologic Technician-Maintenance (CTM) personnel install, configure, diagnose, and repair state-of-the-art electronic, computer, and network hardware/software systems ashore and afloat. These personnel are not typically designated ship's crew personnel (i.e., permanently assigned to a particular unit/vessel). The 2 remaining participants consisted of a Culinary Specialist and a Fire Control Technician (not actively involved with Combat System operations).

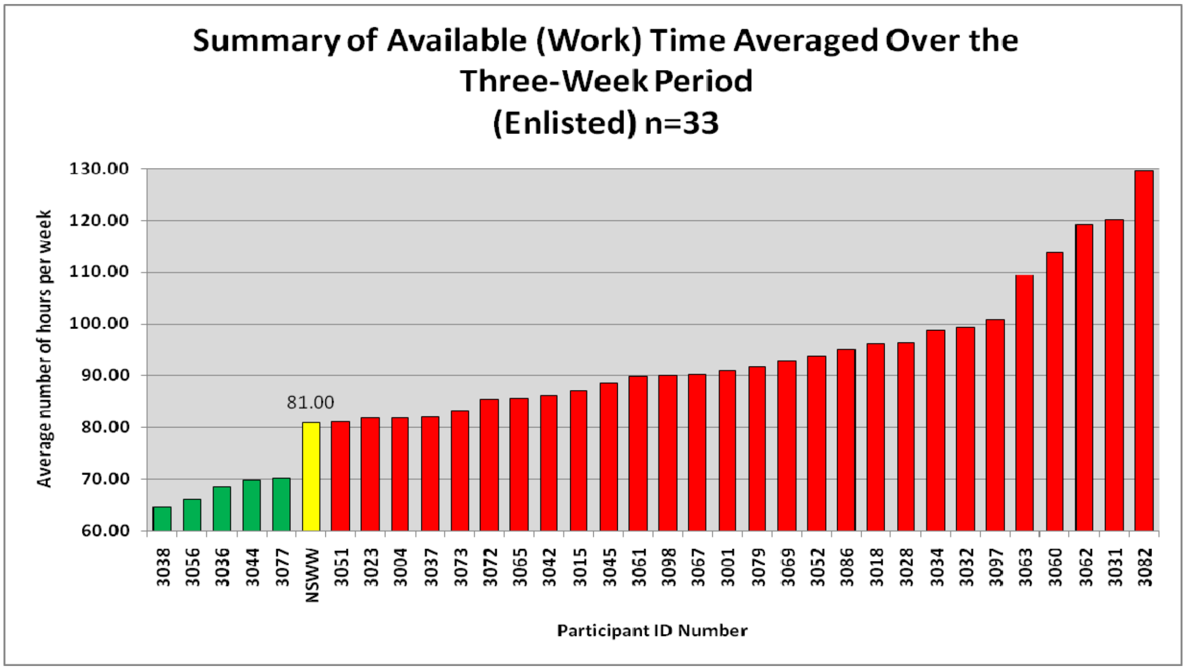


Figure 10. Weekly Average Available Time (Work) for the Three-Week Underway Period

Results for Sailor 3031, Figure 11, contrast the NSWW (shown in yellow) with the reported activities shown in blue. Participant 3031, (a Sonar Technician), had a watch rotation of 6 hours on watch, followed by 6 hours off watch (commonly referred to as “port and starboard” watch schedule). The schedule of Sailor 3031 was fairly consistent from day to day and, on average, he reported standing watch for 11.98 hours per day. This is nearly 4 hours more than the time allotted for watch-standing by the Navy Standard Workweek. Participant 3031 also spent 2.5 hours per day doing maintenance, 30 minutes more than the time allotted by the Navy Standard Workweek. Participant 3031 reported spending 0.89 hours per day in training and 1.79 hours per day in meetings, drastically exceeding the time allotted by the Navy Standard Workweek model (0.57 hours per day).

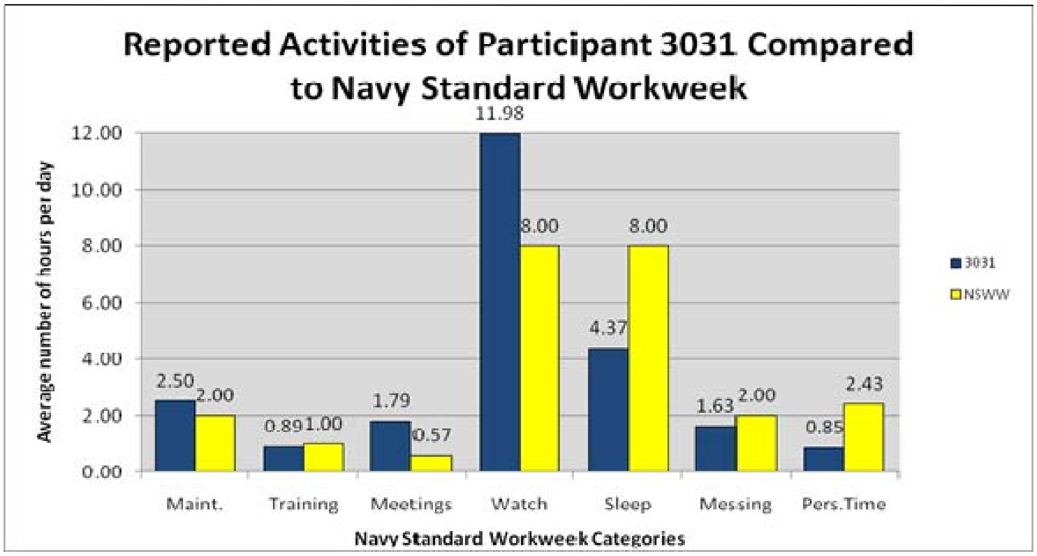


Figure 11. Reported Activities of Participant 3031 as Compared to Navy Standard Workweek

Participant 3031 received an average of 4.37 hours of sleep per day, **55%** (or 3 hours and 38 minutes) less than the time allotted for sleep in the NSWW. Participant 3031 spent an average of 1.63 hours per day messing compared to the 2 hours per day allowed by the Navy Standard Workweek and 0.85 hours per day in combined Personal Time and Sunday Free Time while the Navy Standard Workweek allows for 2.43 hours of personal time per day (daily personal time averaged with 3 hours Sunday free time). Appendix B has each individual Sailor's self-reported time spent working contrasted to the Navy Standard Workweek.

Figure 12 illustrates the difference between the self reported activities of Participant 3031 and the Navy Standard Workweek. The categories of watch, maintenance, and service diversion exceed the time allotted by the Navy Standard Workweek, while time spent in all other categories is less than the time set forth in the Navy Standard Workweek. Specifically, out of the 21 days used for analysis (totaling 168 hours for sleep), Participant 3031 received on-average, **55%** of the sleep allotted by the NSWW (this equates to 76.25 hours fewer hours of sleep) than is allotted by the Navy Standard Workweek model. For this Sailor, the excessive time spent in the watch, maintenance, and service diversion categories accounted for the negative amount of time allotted for sleeping.

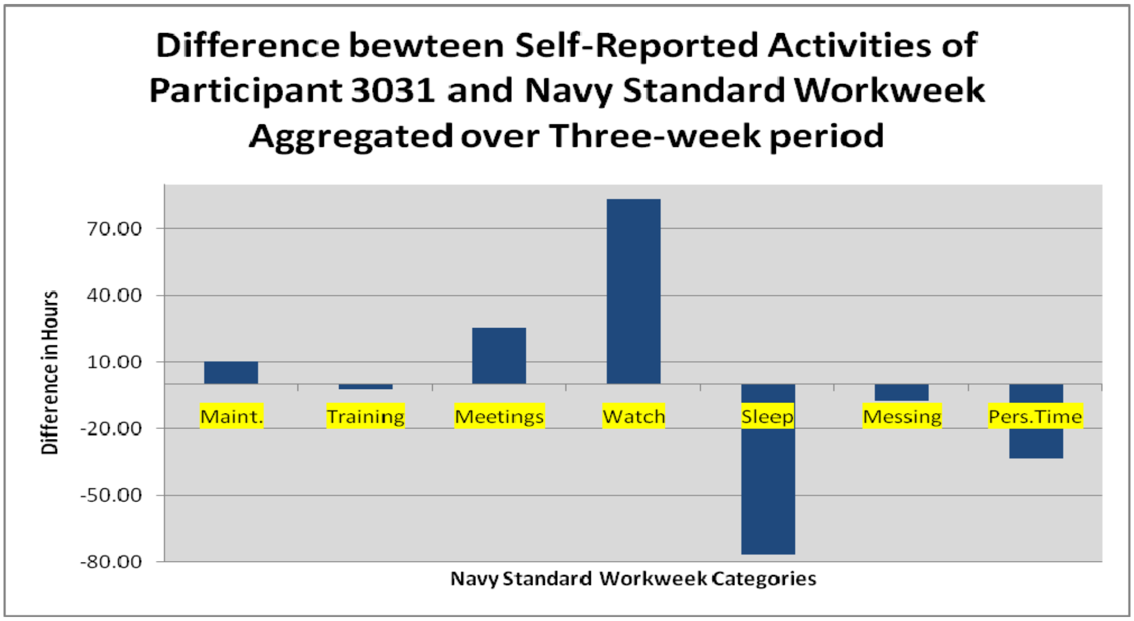


Figure 12. Aggregate Difference between Self-Reported Activities of Participant 3031 and Navy Standard Workweek

Figure 13 illustrates the deviation of activities for Participant 3031 from the Navy Standard Workweek. Calculated using the following formula:

$$\text{Deviation} = \frac{(\text{Reported - Allotted})^2}{\text{Allotted}}$$

Participant 3031 shows the greatest deviation from the Navy Standard Workweek in the categories of service diversion, standing watch, sleeping, and time allotted for personal use. This deviation is an absolute value and, as such, should not be interpreted as either positive or negative, but as a combination of both. The difference in the number of hours used for watch and meetings exists due to the various phases of the exercise. During certain time periods of the exercise, operations requiring numerous meetings and watch-standing duties were necessary to coordinate with the other vessels participating within the exercise. Upon completion of the coordinated evolution (i.e., submarine detection and tracking), watch-standing duties and meetings subsided. This explains the large deviation in hours attributing to Participant 3031.

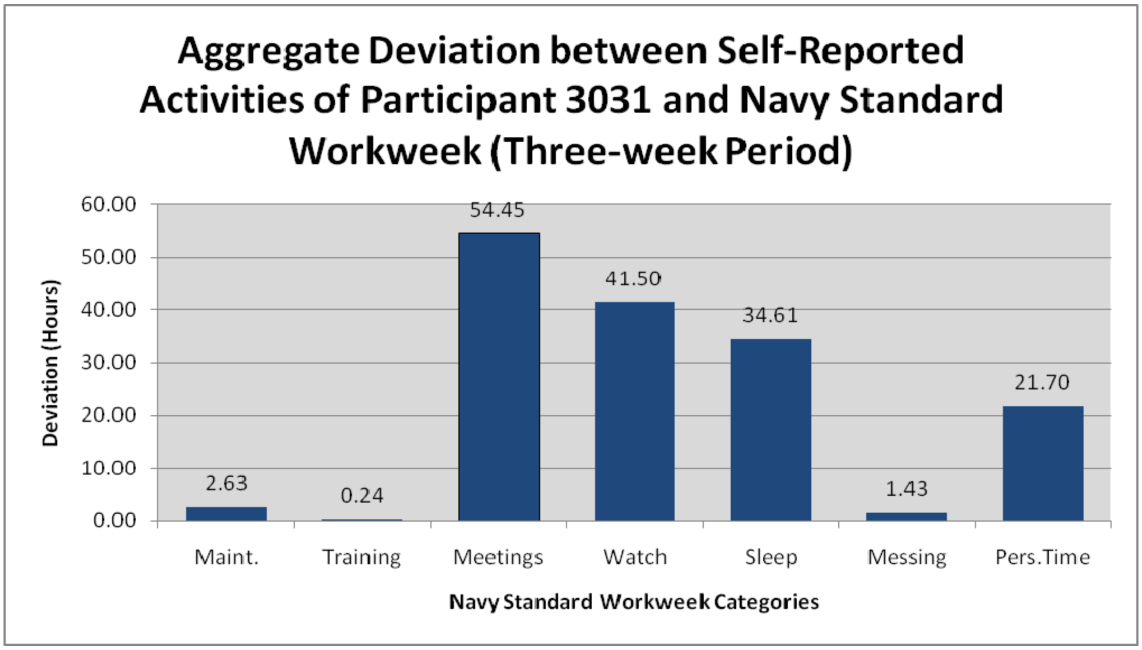


Figure 13. Deviation between Self-Reported Activities of Participant 3031 and Navy Standard Workweek

Combat Systems Department, on average, worked 15 hours more per week than the “available” 81 hours allotted by the Navy Standard Workweek model throughout the three-week underway period (see Figure 14). In particular, participants 3031, 3060, and 3062 (Sonar and Fire Control Technicians) consistently averaged over 100 hours per week of “available time” throughout the study, either standing watch or performing maintenance. Operations Department participant’s averaged approximately 5 more hours than the allotted 81 hours of weekly available time; the combination of the 7 participants from Engineering, Supply, and Administration Departments averaged almost 8.5 more hours than the Navy Standard Workweek. Further analysis of the distribution of allotted hours by NSWW categories have been depicted in Figures 15–21.

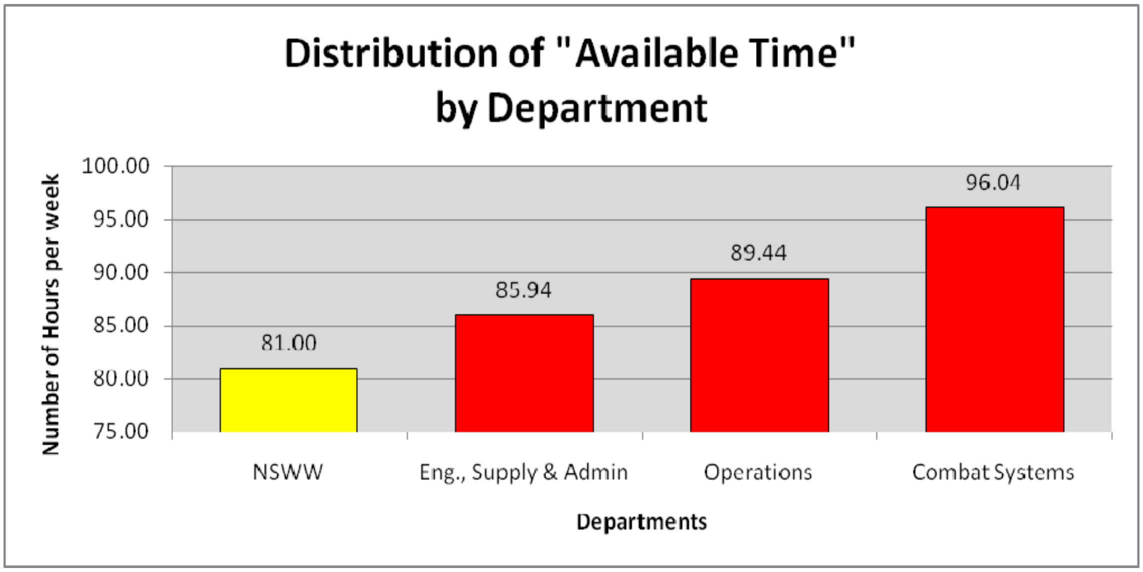


Figure 14. Mean Distribution of Available Time by Department

Figure 15 illustrates the three-week average of the number of hours participants spent on Watch. The NSWW model suggests that watch-standers should stand, on average, 8 hours of watch per day, or 8 hours a day performing maintenance if not assigned a watch-standing position. In a majority of the cases throughout the exercise, participants were tasked with 8 hours of watch in conjunction with 8 hours of performing maintenance, thereby severely impacting the number of hours the participant was able to fulfill the “Non-Available” prescribed hours of personal free time. Nineteen of the 33 participant’s (57%) data entries regarding watch-standing indicate that recorded responses pertaining to Watch accounted for 9 or more hours per day. Of those 19, nine of the participants that exceeded the NSWW model were assigned to the Operations Department.

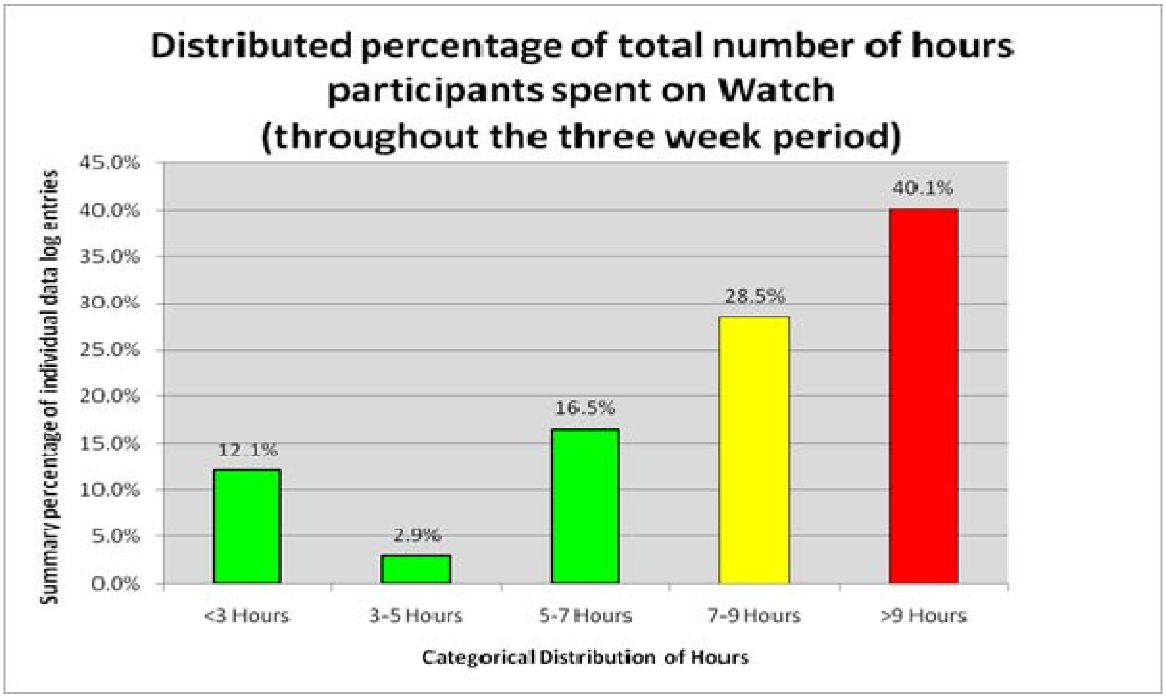


Figure 15. Distributed Percentage of Total Number of Hours on Watch

Operations Department

The 15 participants in the Operations Department averaged more than one hour of additional time standing watch (9.15 hours) and an additional 45 minutes performing maintenance (2.74 hours) to that allotted by NSWW throughout the three-week period. Conversely, Operations Department slept approximately one hour less than allotted by the Navy Standard Workweek model (7.29 hours). See Figure 16 and 18. The time allotted for maintenance, watch, and personal time were exceeded in each category, directly affecting time available for training, sleeping, and messing. Although the time allotted for personal free time was exceeded throughout the study for Operations Department, that additional time used was not adequate enough to offset the time that could have been directed toward sleeping or messing. Deviation for personal time from the NSWW model only accounts for an average of 18 minutes per day that could have been used elsewhere.

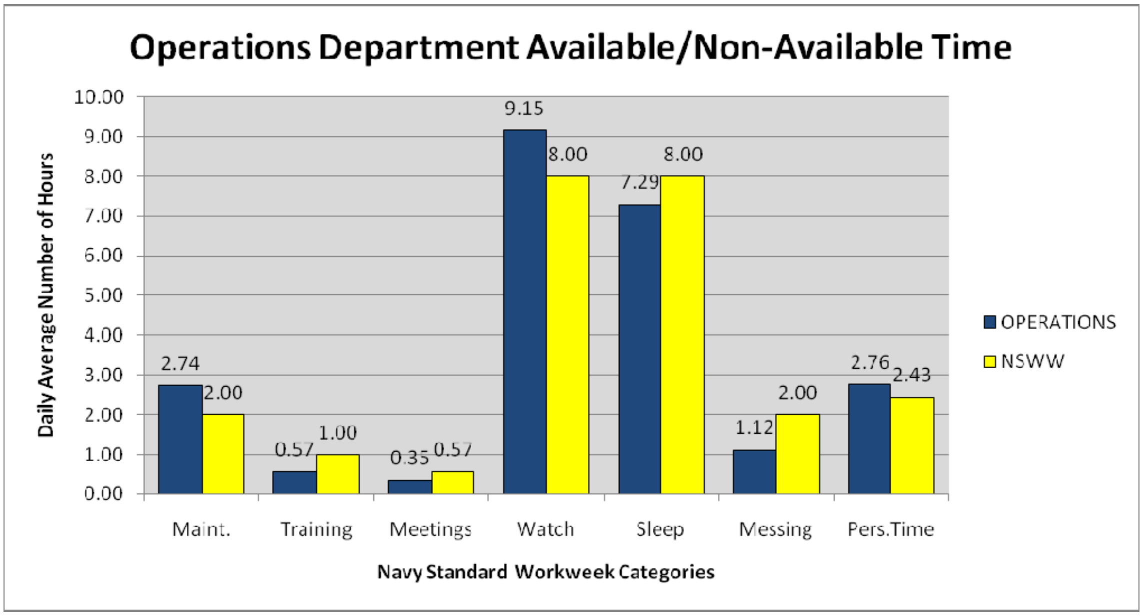


Figure 16. Operations Department Average Available/Non-Available Time as Compared to Navy Standard Workweek (Three-week period) n=15

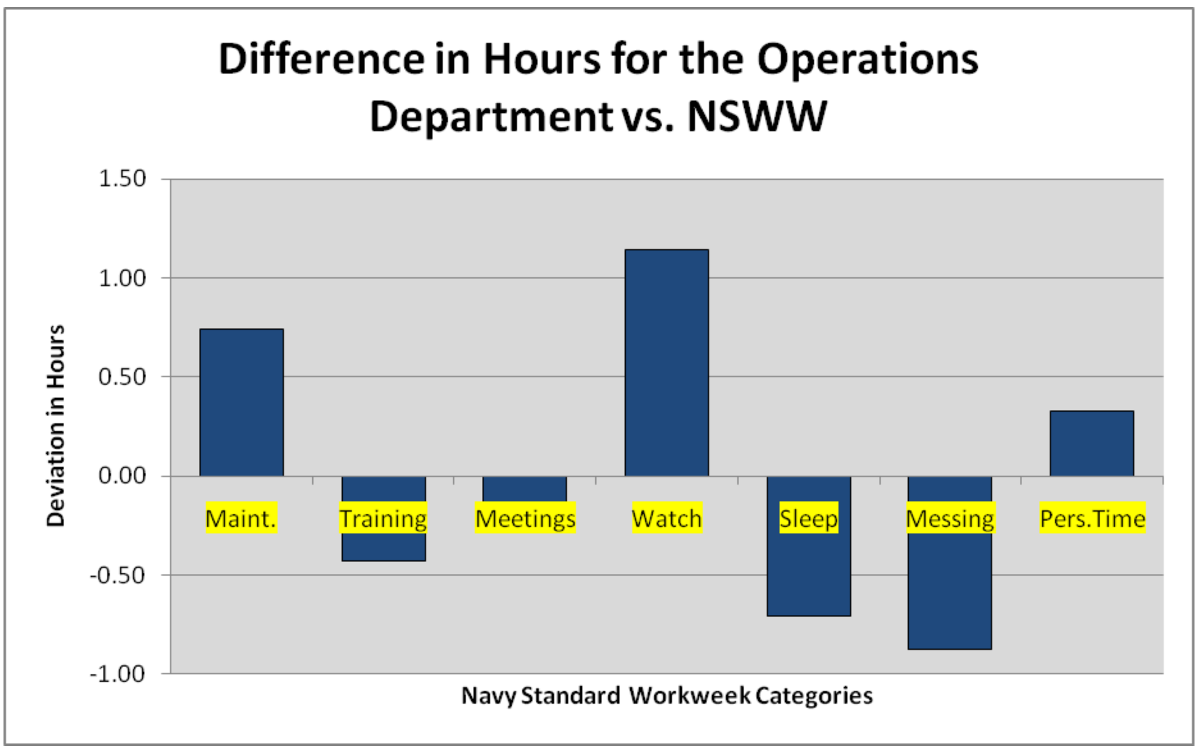


Figure 17. Difference in Hours for the Operations Department as Compared to Navy Standard Workweek

Combat Systems

Averaging an extra 2 hours per day, in addition to the allotted 2 hours by the Navy Standard Workweek, Combat Systems Department performed 8 hours of watch and 4 hours of maintenance throughout the exercise (see Figure 18 and 19). Figure 18 depicts the difference in hours for the Combat Systems Department as compared to the Navy Standard Workweek. Most notable is the excess amount of time used to perform maintenance. This phenomenon can be explained by the additional requirements produced from the use of various weapons systems placed in operation for the exercise. Immediately following the discharge of any weapon system, maintainence is required to correct and/or prevent future degradation of equipment.

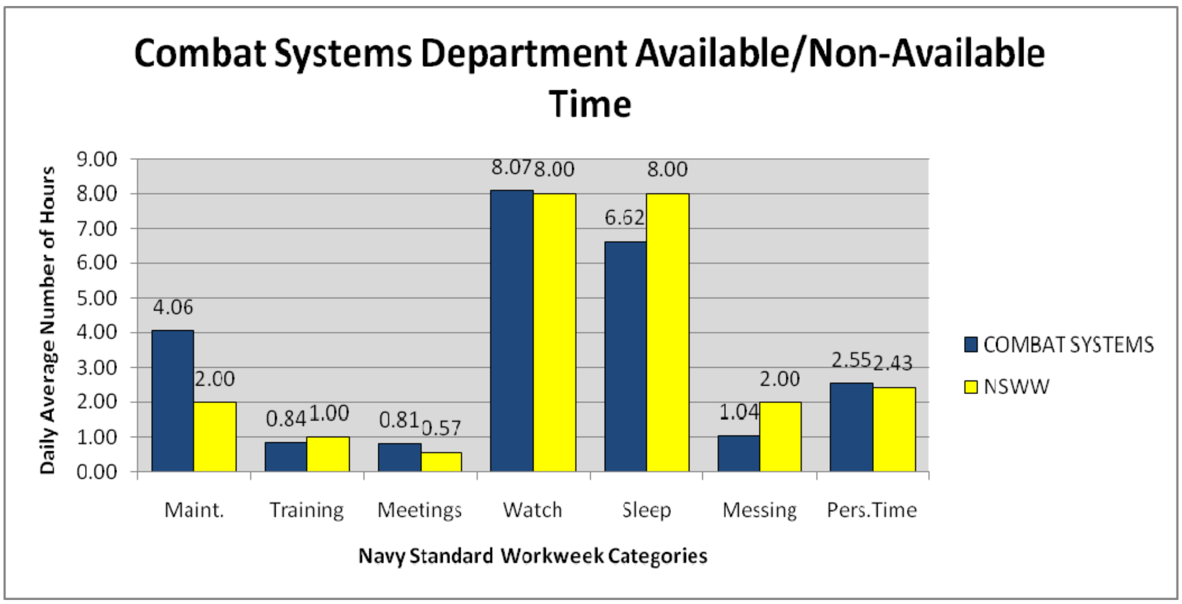


Figure 18. Combat Systems Department Available/Non-Available Time as Compared to the Navy Standard Workweek (Three-week Period) n=11

In general, each "Available Time" category remains consistent with the NSWW model with the exception of the maintenance category. The additional 2 hours dedicated to maintenance directly affects the allotted time for sleeping and messing, causing Combat System Department Sailors to forego 2 hours of "Non-

Available time" allotted by the NSWW. As a department, Combat System participants averaged just over 6.5 hours of sleep and 1 hour of messing per day. Considering the fact that both ships showed similar results, it would appear that Combat Systems Department is overtasked.

Eighty-one percent of Combat Systems Department averaged between 5-to-7 hours of sleep per day. This may be in part due to the maintenance required to service equipment following live-fire exercises; however, the Navy Standard Workweek does not distinguish nor differentiate between actual combat, live-fire exercises, or the like. Given the circumstances, 6 hours of sleep is an inadequate amount of rest for anyone to consistently perform at optimum levels for a sustained period of time.

These findings suggest that there are slight differences between departments regarding the use of available and non-available time. Operations Department averaged one additional hour of watch compared to the NSWW model, as opposed to Combat Systems Department, whose weekly allotted time for were in congruence with the Navy Standard Workweek model. Conversely, Combat Systems Department reported maintenance hours were approximately 1.5 hours more than the Operations Department. A comparison between both ships exhibit similar findings regarding the number of hours performing maintenance and standing watch (Appendix F). Statistically, there are no differences between ships regarding the several categories and the Navy Standard Workweek.

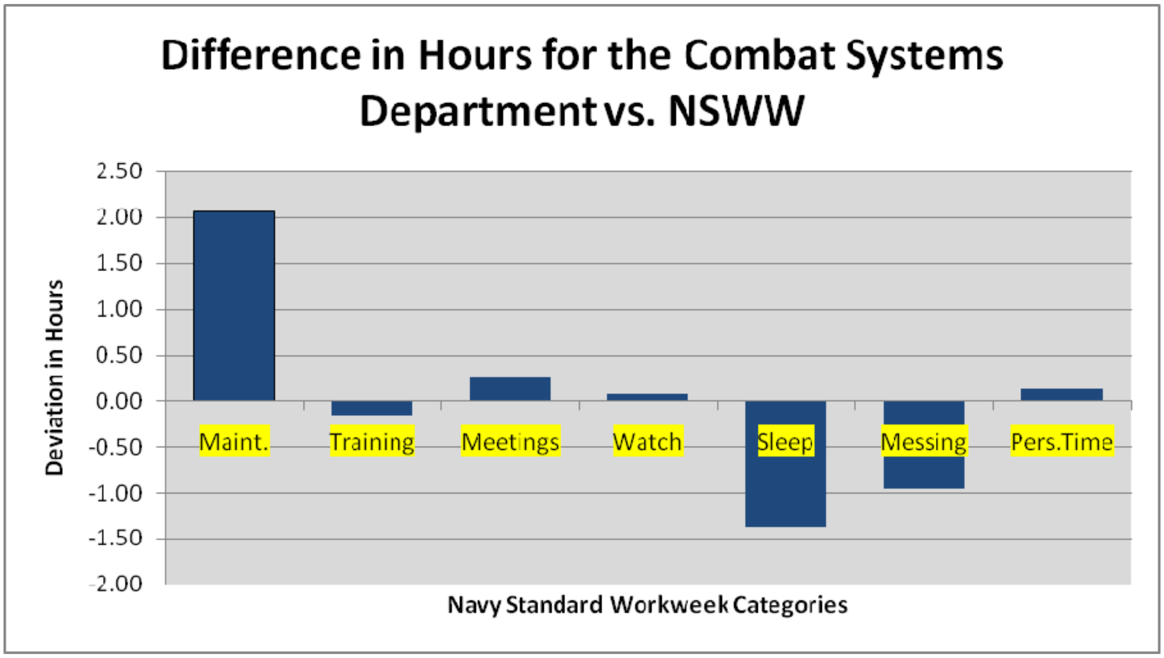


Figure 19. Difference in Hours for Combat Systems Department as Compared to the Navy Standard Workweek

Engineering, Supply, and Administration Departments

Engineering, Supply, and Administration Departments were combined for the purpose of this study due to the limited number of participants from each group (n=7). The data from this group is seen in Figure 20. Similar to the Combat Systems Department, the 7 participants collectively exceeded the amount of time allotted for productive work according to the Navy Standard Workweek model. In particular, maintenance accounted for an extra 1.5 hours in addition to the 2 hours allotted by the NSWW model. In turn, time dedicated for sleeping and messing were affected by as much as one hour. Figure 21 depicts the difference in hours for Engineering, Supply, and Administration departments. Again, due to the limited number of participants that volunteered from the Engineering, Supply, and Administrative Departments, no statistical inference could be made to conduct a comparative analysis between ships.

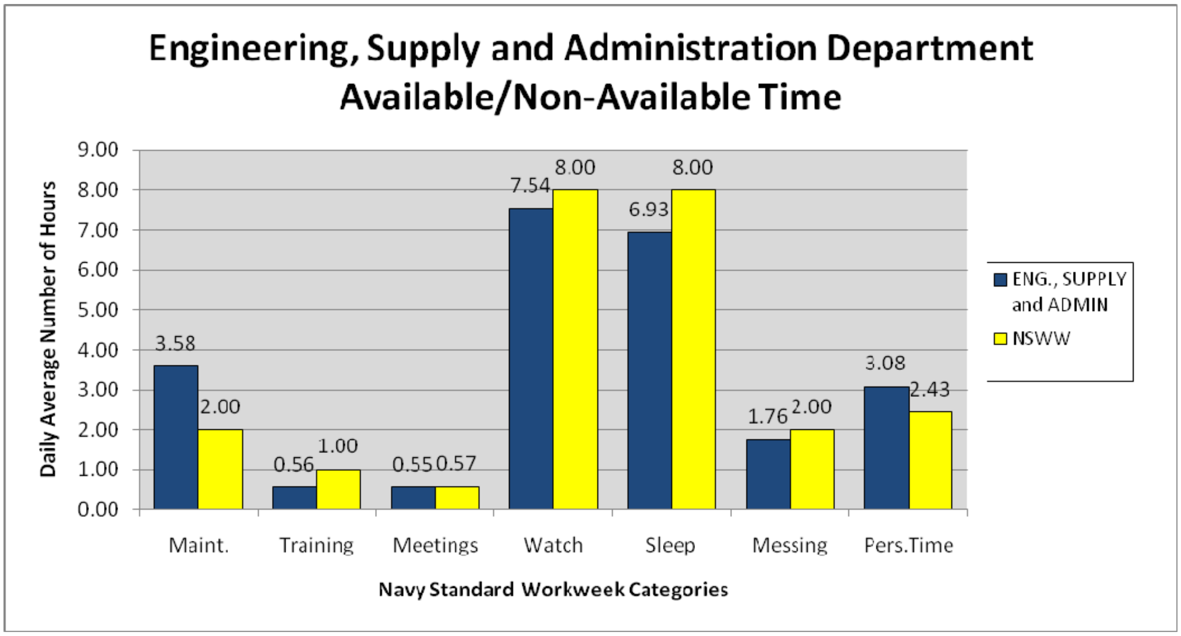


Figure 20. Engineering, Supply, and Administration Department Available/Non-Available Time as Compared to Navy Standard Workweek (n=7)

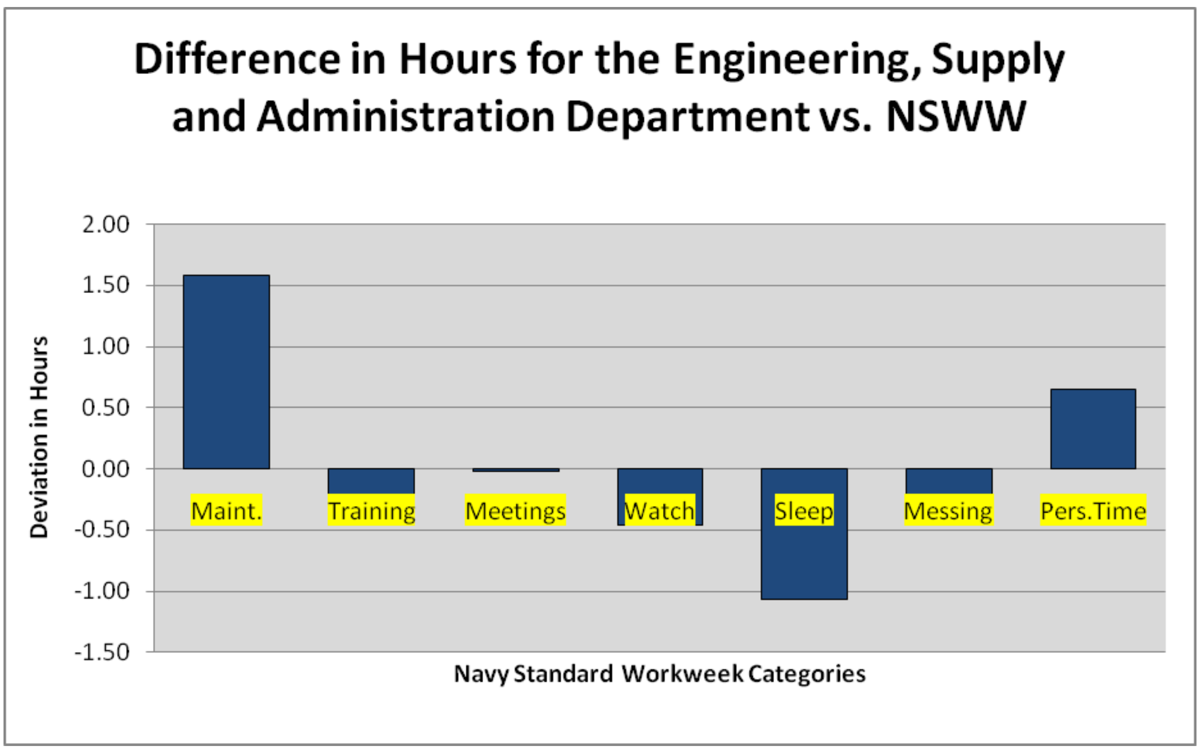


Figure 21. Difference in Hours for Engineering, Supply, and Administration Department as Compared to Navy Standard Workweek

Figures 22 through 27 show distributions of the remaining five Available and Non-Available hours allotted for participants within the study. As the total number of events recorded indicates (663 total), 58% of the responses noted were at or above the time allotted for performing maintenance as compared. Only 51**%** of the participants received the allotted amount of personal time set forth by the Navy Standard Workweek model.

In the following graphs, “red” bars indicate a negative, or significantly greater amount of time participants reported spending within the respective categories, compared to the NSWW model. For instance, hours that exceed the NSWW model for maintenance are negatively indicated in red, whereas, in categories such as Personal Time, Messing, and Sleep, red bars indicate that the participants received less time than allotted for in the model. The “green” bars indicate a positive, or more time spent in that activity as compared to the NSWW model. Finally, the “yellow” bars indicate the allotted number of hours the NSWW model suggests each participant should receive, or be accountable for, throughout the 168 hour workweek.

Figure 22 illustrates that just over half of the participants actually fit into the NSWW model for maintenance, with 46% of the recorded responses indicating that on average, 3 or more hours were spent conducting maintenance in addition to 56 hours of watch-standing duties. Weekly summary averages for all participants range from 21–23 hours performing maintenance, with standard deviations that suggest participants either conducted zero maintenance hours during the week or an excess of 40 hours per week dependent upon the participant’s rank and rating.

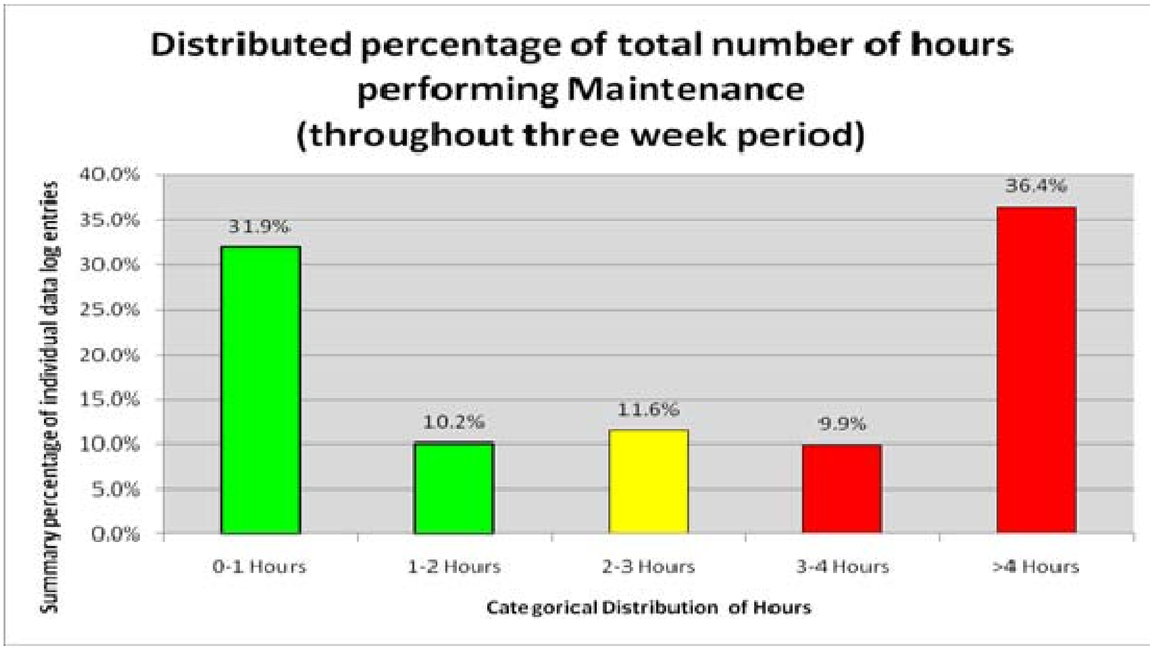


Figure 22. Distribution of Time Spent Performing Maintenance

As illustrated in Figures 23 and 25, only 52% of the participant responses indicated that they received the required 2 hours or more of personal time and merely 18% of the participant's responses accounted for the 2 hours time to mess (the allotted time to eat), as compared to the Navy Standard Workweek model. This wide disparity suggests that the model does not accurately estimate how Sailors distribute their time.

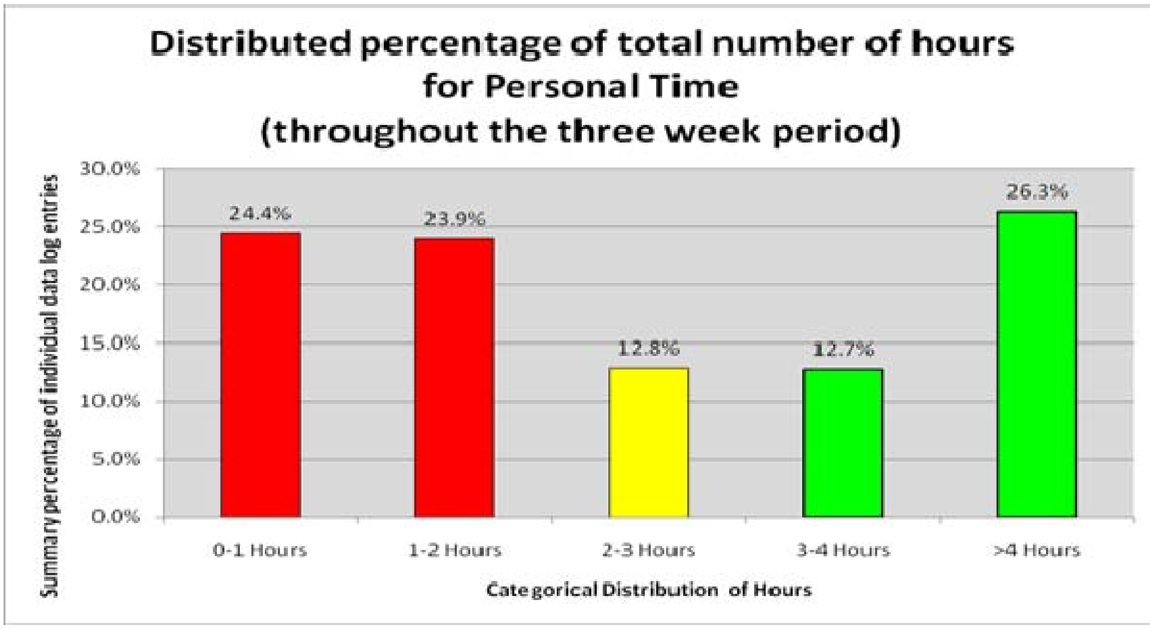


Figure 23. Distributed Percentage of Time for Personal Time

Each Sailor is allotted at least one hour daily to conduct training. Analyses indicate that 79% of the participants conducted less than one hour of training as indicated by the daily sleep and data log entries (see Figure 24). According to the summarized individual data responses regarding training, 85% of the participants averaged between 25 to 45 minutes daily allocated time by the NSWW model (Appendix F). These findings pose an extensive problem with the NSWW model considering the impact of the reduction of billets and available resources regarding formal schoolhouse training for several combat intensive ratings.

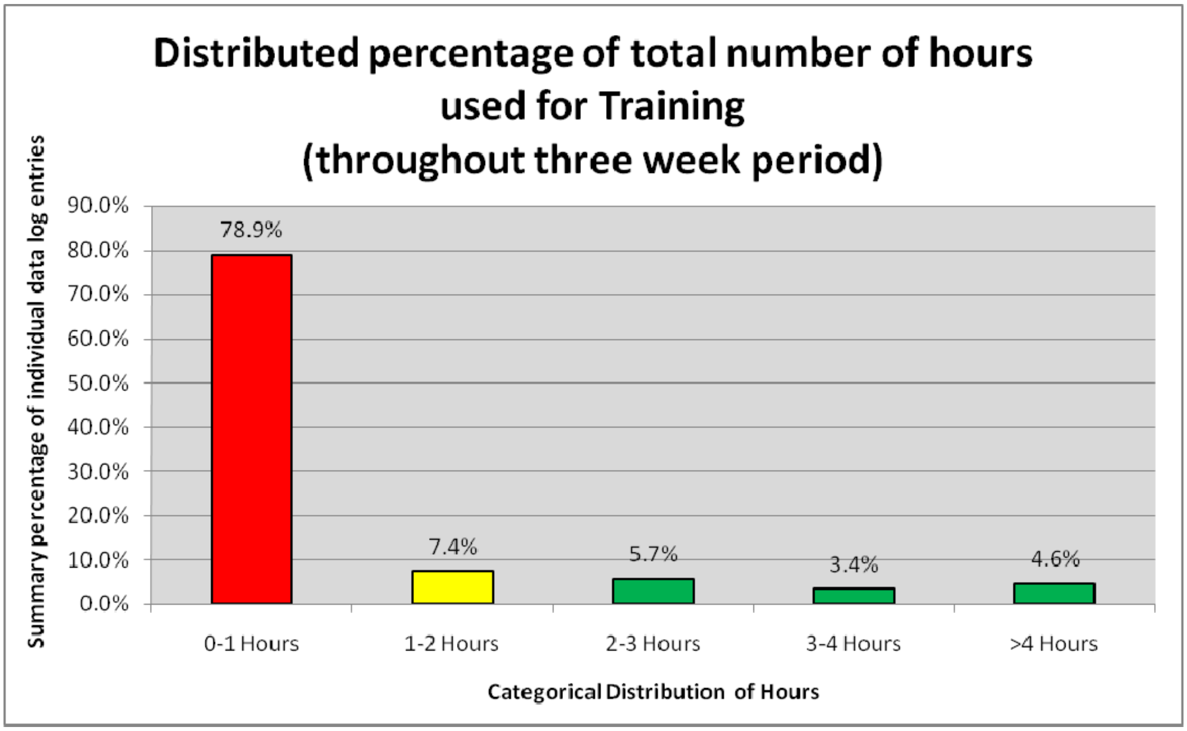


Figure 24. Distribution of Time Spent in Training

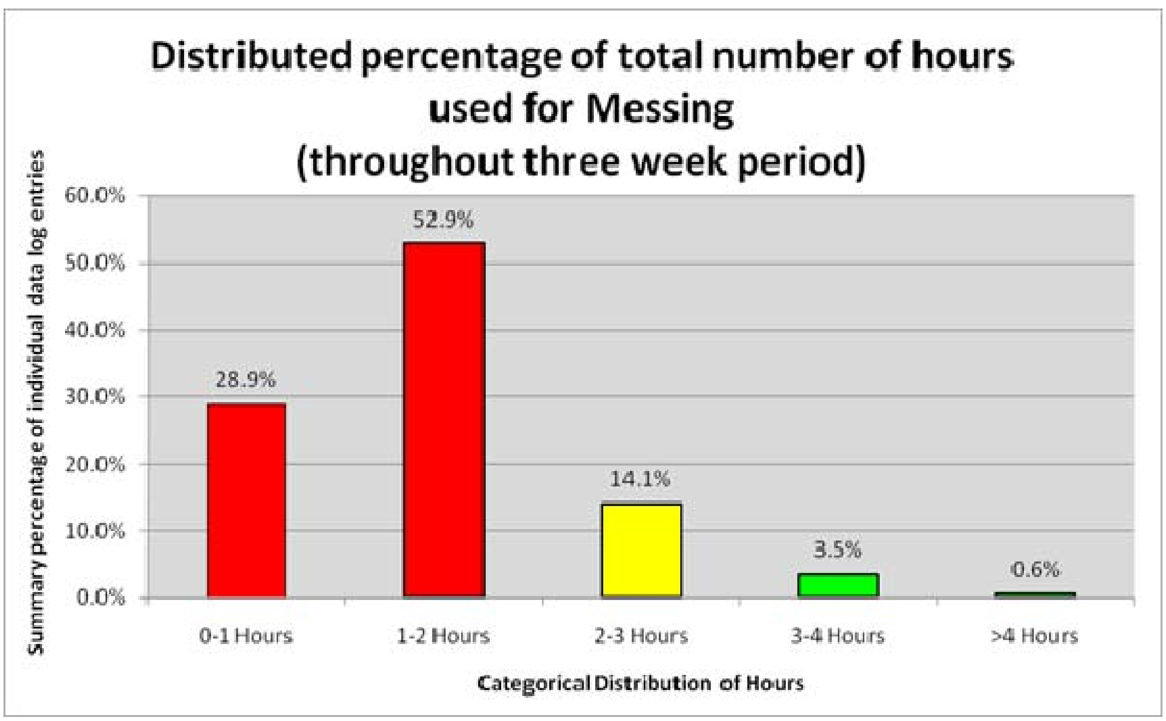


Figure 25. Distribution of Time Spent Messing

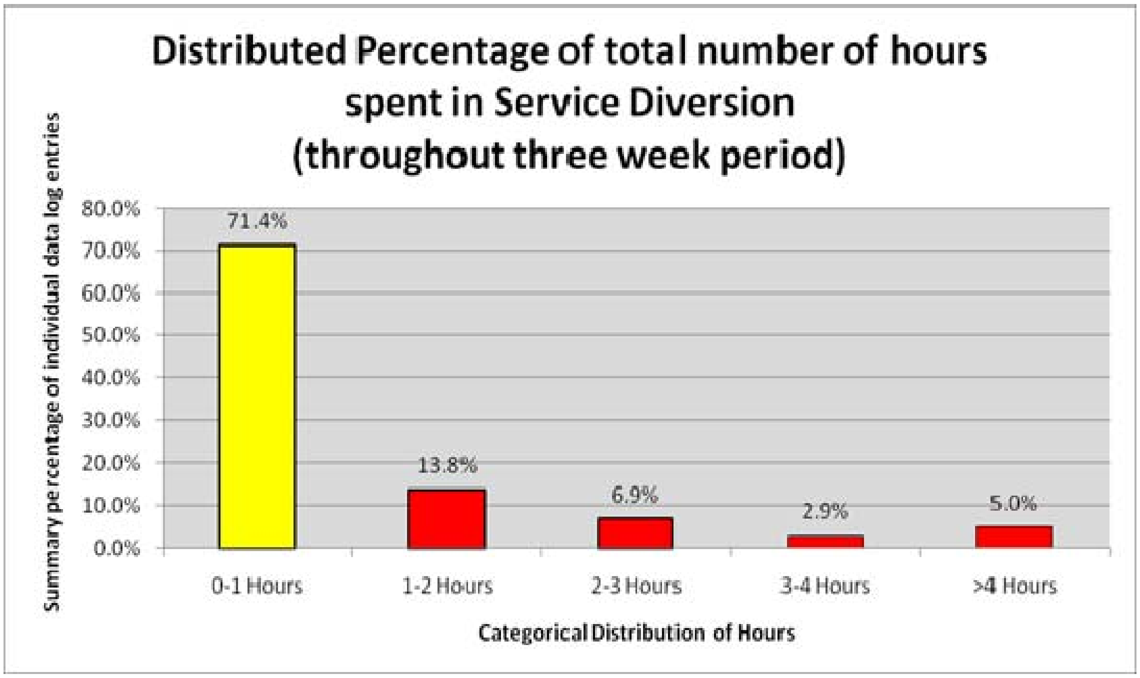


Figure 26. Distribution of Time Spent with Service Diversion

Figure 27 is a summary distribution of the total number of hours participants spent sleeping throughout the three-week underway period. The graph illustrates the 33 enlisted participants' responses. Of the total number of recorded events manually entered on the Sleep and Data Log, only 51% of the responses accurately reflected participants receiving 7 or more hours of sleep (validated through Actigraph analysis). There appeared to be some disparity between actual sleep, recorded by Actiwatch, and the number of hours Sailors reported sleeping.

Participants consistently overestimated the amount of sleep they received daily. For instance, rather than noting the actual time the participant may have fallen asleep, many of the participants listed the time when they initially laid to rest rather than the time they began sleeping. Final analysis of the data log sheets and Actiwatch indicate 84**%** of the participants (excluding Officers) were categorized as falling below the Navy Standard Workweek sleep allotment, averaging just over 47 versus 56 hours of sleep per week (see Appendix C).

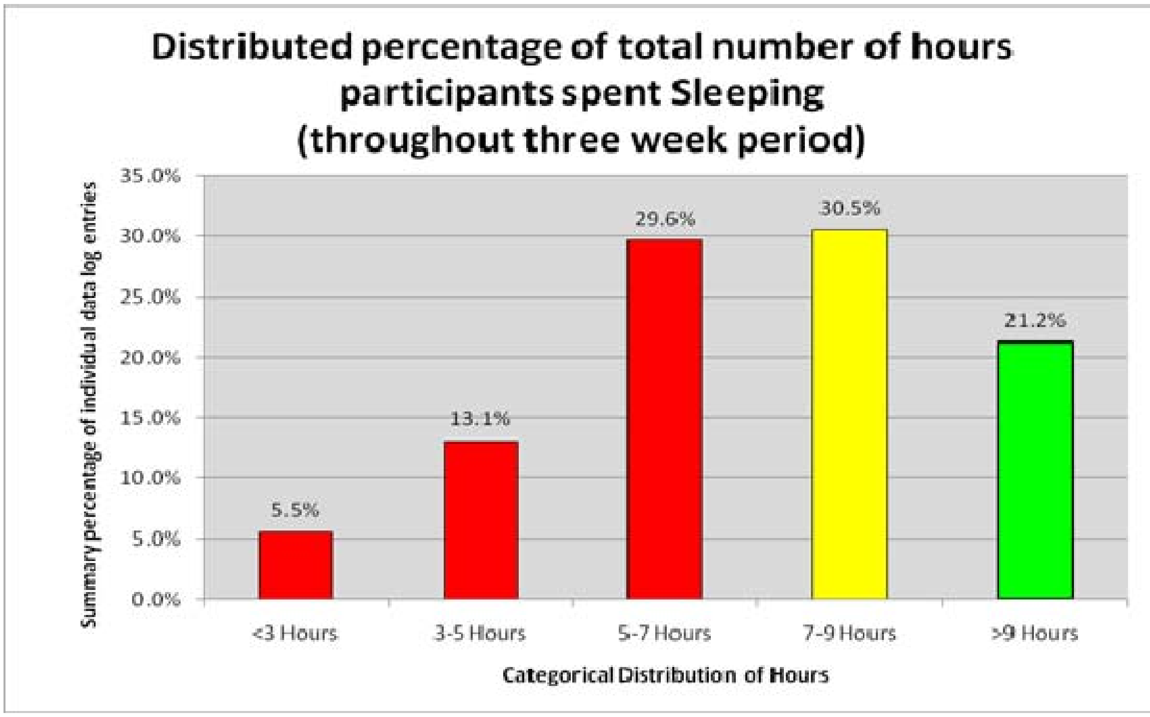


Figure 27. Distributed Percentage of Time Spent Sleeping

Portraying similar results to those of the Haynes (2007) study, time allotted for maintenance appears to be grossly under-estimated. In particular, Combat Systems Department maintenance hours are much higher than allowed in the NSWW which indicates an inadequacy of the Navy Standard Workweek model. Results indicate that the NSWW model does not accurately reflect the required maintenance time performed by Combat Systems personnel. The maintenance actions required following actual combat, live-fire exercises, or the likeness of any event that may directly impact the scheduling of available and non-available allotted hours must be accounted for and accurately reflected if the NSWW model will continue to be used for manning purposes.

C. FAST RESULTS

As previously stated, Actigraphy data entered into the Fatigue Avoidance Scheduling Tool (FAST) allows for the prediction of the effectiveness of each individual. For the purposes of this study, Sailor 3031, representing the worst case, was used to depict the lowest predicted effectiveness of participants within the study (see Table 3 and 4). Analyses from all participants varied significantly dependent upon rank and type of watch position assigned.

As illustrated in Table 3, participant 3031 (a designated 2nd Class Petty Officer Sonar Technician from USS LAKE ERIE) continuously operated in the red zone with an average effectiveness level of performance varying between 52% and 53%. At these levels, regardless of task assigned, the participant's predicted effectiveness or blood alcohol equivalency was similar to that of a person operating a motor vehicle with a blood alcohol content greater than 0.08%. Eighteen of the 33 participants (54%) within the study, showed similar results with average effectiveness levels at, or lower than the 65% performance measurement.

Figure 28 is the three-week FAST profile for Sailor 3031. The red shading located along the predicted effectiveness line and at the bottom of the graph indicate the time when Sailor 3031 reported either being on watch, conducted maintenance, or engaged in training. The predicted effectiveness of Sailor 3031 began to trend downward on the second day, and after getting underway fell below the critical 65% predicted effectiveness level. Sailor 3031 had disrupted sleep throughout the underway period. This fact, coupled with the constantly rotating watch shift, resulted in Sailor 3031 operating at less than a 65% predicted effectiveness level throughout the remaining operational period. As a result, Sailor 3031 never reached the 90% predicted effectiveness level.

Participant 3031					
Entire schedule		Intervals			
Total Days	22		Work	Wake	Sleep
First	7/8/2008	N	94	26	25
Last	7/29/2008	Mean	250.5	1029.2	190.2
Average Sleep per Day	223	Median	225	1185.0	195.0
Average Work per Day	1071	SD	197.3	580.5	79.9
Average Effectiveness	52.90	Shortest	45	45	75
		Longest	1155	2445	405
		Avg.Eff.	52.80	52.95	52.70

Table 3. FAST Analysis of Participant 3031

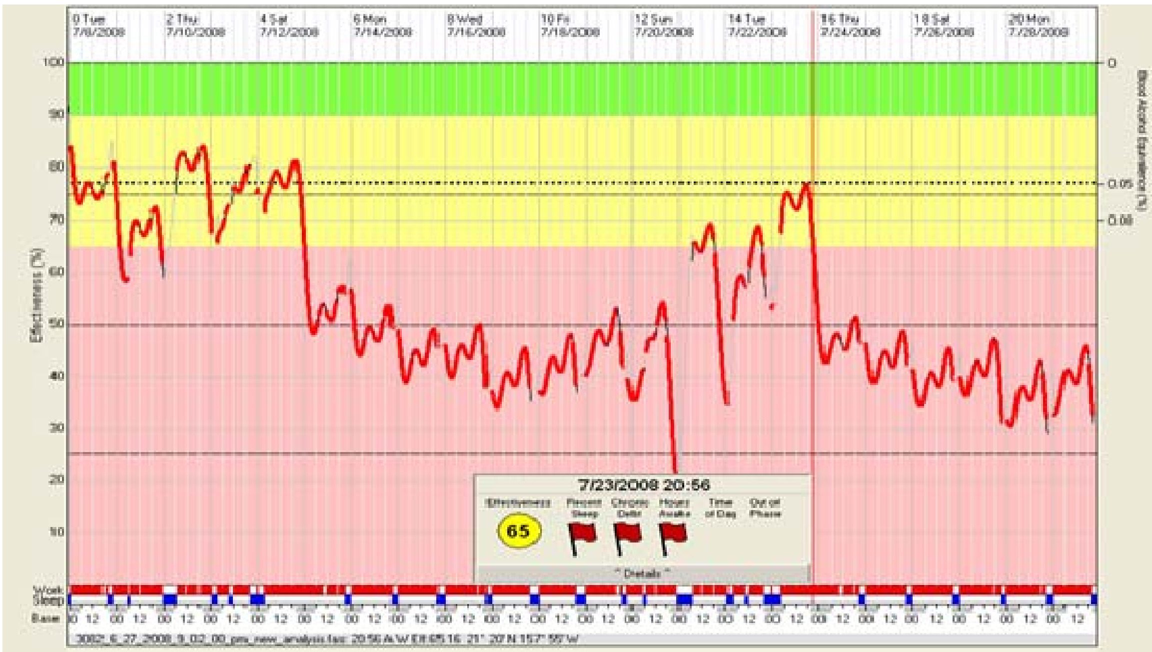


Figure 28. FAST Plot of Participant 3031

V. DISCUSSION AND RECOMMENDATIONS

A. DISCUSSION

The purpose of this study was to determine if the U.S. Navy underestimated the total number of hours each Sailor work each week onboard U.S. Navy cruisers; to determine if the work/rest patterns of U.S. Navy cruiser Sailors and their departments differ in terms of the work they conduct; and to determine if the U.S. Navy Standard Workweek requires a revision to accurately reflect requirements of Sailors in various departments throughout the ship.

The Navy Standard Workweek model does not accurately reflect the activities of U.S. Sailors onboard U.S. Navy cruisers. As previously noted, results indicate that 85% of the participants within the study exceeded the 81 hours of available time allotted by the Standard Navy Workweek. On average, Sailors in the current study, excluding Officers, worked 9.90 hours more per week than allotted by the Navy Standard Workweek model; equating to 1.41 hours more per day in available time. The Haynes (2007) study found similar results. Consequently, the additional hours of available time used are taken away from the non-available time allotted to each Sailor.

Additional findings of this thesis suggest that the Navy Standard Workweek does not accurately reflect the activities of today's Sailors. In particular, Combat Systems Department performing maintenance and Operations Department watch-standing duties on U.S. Navy cruisers are underestimated by as much as 2 hours per Sailor. Overall, the USS PORT ROYAL (CG 73) and USS LAKE ERIE (CG 70) displayed similar findings in all categories of the Navy Standard Workweek. In fact, similarities between the two ships were so common; the pooling of Combat Systems and Operations Department participants from each ship was made possible. Although 7 of the participants from Engineering, Administrative, and Supply Departments were collectively assigned to the same unit, findings do suggest the 2 participants from the Engineering Department perform an additional 2 hours of maintenance allotted by the Navy Standard Workweek.

It is important to note the subtle differences noted regarding Combat Systems Department, Operations Department, and the Navy Standard Workweek model throughout this thesis. In particular, Operations Department hours allotted to watch by the NSWW was exceeded by 1 hour throughout the study, and Combat Systems Department maintenance hours were exceeded by 2 hours. Based on these findings, the Navy Standard Workweek model underestimates the number of hours Sailors spend standing watch and performing maintenance in varying Departments.

This exercise was by no means a true test of actual combat, however; the simulations experienced throughout the three-week period were as close to actual warfighting scenarios as possible without placing the lives, and various ships which participated, in harm’s way. Under different circumstances, (e.g., actual combat), it is conceivable that the body, acting under extreme mental and physical duress could respond differently; either performing at an optimal performance level or suffering a deterioration of learned skilled sets. Further analysis could be conducted to explore this possibility.

Traditionally, the general rule for minimizing sleep loss is to ensure that personnel have a routine approach to obtaining sleep. Adequate time and an appropriate sleep environment are also required to obtain sufficient sleep. Sailors, and their leaders continuously engaged in shiftwork, should be mindful of sleep debt incurred while conducting sustained operations at sea. They need to know that it takes time to allow the body to adapt to environmental changes. Although the body may never truly adapt to shiftwork schedule and the resulting change in sleep habits, every effort should be made to gradually adjust to new patterns of sleep.

B. RECOMMENDATIONS

Further research regarding the work/rest pattern of Sailors should be conducted with a complete compliment of the crew onboard several vessels in order to revise the NSWW model. With the induction of the “Smart Ship” into the U.S. Navy fleet, future research should be conducted on how technology has alleviated many of the watch and maintenance hours required to maintain sustained operations at sea. Built on the premise that these vessels reduce manpower and workload requirements, research should be conducted to capture the work/rest patterns of their Sailors and to assess how well the Navy Standard Workweek model aligns with these newly configured ships.

Educating military commanders on the consequences of sleep deprivation and ways to combat sleep debt in order to optimize performance, is a major step needed in addressing fatigue and sleep related problems. The “Warrior Ethos” culture of surface community Officers, and Enlisted Sailors alike, needs to be addressed fleet-wide.

With so much emphasis placed on the Navy Standard Workweek in the determination of manpower requirements, the NSWW model should accurately reflect the requirements of U.S. Navy Sailors. Departments vary considerably in their deviation from the Navy Standard Workweek, and while some personnel show little deviation in categories by rating, others deviate greatly from the Navy Standard Workweek model by rank. Each department has different requirements and responsibilities, and each person is held more accountable with increasing responsibilities as they progress throughout their careers. It is inconceivable to assume that each department (or each rating for that matter), will operate at the same standard or that every individual operates to that standard. The Navy Standard Workweek should be revised using a metric, not just determined by the number of bodies present onboard a particular class ship, but constructed to include the additional qualifications needed to determine the manpower requirements for all Departments.

In closing, there are significant individual differences in tolerances to sleep loss, and the U.S. Navy must recognize that fact. In both sustained combat operations, and training, requirements go far beyond physical endurance. Due to the cognitive work and mental stress involved, unit commanders should consider the unique aspects of sustained operations when conducting Operational Risk Management (ORM) briefings. Commanders should identify areas where reliance is on the performance of a few individuals and lessen such dependence when feasible (i.e., cross-train personnel, or augment personnel when available). Ideally, Commanders should implement a work/rest schedule and sleep discipline plan for their individual units and adhere to it. Crew morale and motivation factors alone are not sufficient to maintain peak performance levels required while conducting sustained operations at sea.

APPENDIX A. PARTICIPANT CONSENT FORM, MINIMAL RISK STATEMENT, PRIVACY ACT STATEMENT

Naval Postgraduate School
Participant Consent Form & Minimal Risk Statement

Introduction. You are invited to participate in a study entitled A COMPARATIVE ANALYSIS BETWEEN THE NAVY STANDARD WORKWEEK AND THE WORK/REST PATTERNS OF SAILORS ABOARD U.S. NAVY CRUISERS being conducted by the Naval Postgraduate School Operations Research Department.

Procedures. If I agree to participate in this study, I understand I will be provided with an explanation of the purposes of the research, a description of the procedures to be used, identification of any experimental procedures, and the expected duration of my participation. *Synopsis*: (1) You may be asked to wear a wristwatch data collection device continuously, to include normally scheduled sleep periods. (2) You will be asked to fill out a log with specific information related to your schedule, particularly times related to sleep and rest periods.

Risks and Benefits. I understand that this project does not involve greater than minimal risk and involves no known reasonably foreseeable risks or hazards greater than those encountered in everyday life. I have also been informed of any benefits to myself or to others that may reasonably be expected as a result of this research.

Compensation. I understand that no tangible reward will be given. I understand that a copy of the research results will be available at the conclusion of the experiment.

Confidentiality & Privacy Act. I understand that all records of this study will be kept confidential and that my privacy will be safeguarded. No information will be publicly accessible which could identify me as a participant, and I will be identified only as a code number on all research forms. I understand that records of my participation will be maintained by NPS for five years, after which they will be destroyed.

Voluntary Nature of the Study. I understand that my participation is strictly voluntary, and if I agree to participate, I am free to withdraw at any time without prejudice.

Points of Contact. I understand that if I have any questions or comments regarding this project upon the completion of my participation, I should contact the Principal Investigators, Dr. Nita Lewis Miller, DSN 756-2281, nlmiller@nps.edu or LT Derek R. Mason, USN, (831) 324-0766, dmason@nps.edu. Any medical questions should be addressed to LTC Eric Morgan, MC, USA, (CO, POM Medical Clinic), (831) 242-7550, eric.morgan@mw.amedd.army.mil.

Statement of Consent. I have read and understand the above information. I have asked all questions and have had my questions answered. I agree to participate in this study. I will be provided with a copy of this form for my records.

______________________________________ Date ____________________
Participant's Signature

______________________________________ Date ____________________
Researcher's Signature

Privacy Act Statement

1. Authority: Naval Instruction

2. Purpose: Activity levels, and watch rotation data will be collected to enhance knowledge, and to develop recommendations for scheduling practices of Naval Surface Sailors.

3. Use: Data will be used for statistical analysis by the Departments of the Navy and Defense, and other U.S. government agencies, provided this use is compatible with the purpose for which the information was collected. Use of the information may be granted to legitimate non-government agencies or individuals by the Naval Postgraduate School in accordance with the provisions of the Freedom of Information Act.

4. Disclosure/Confidentiality:

> a. I have been assured that my privacy will be safeguarded. I will be assigned a control or code number, which thereafter will be the only identifying entry on any of the research records. The Principal Investigator will maintain the number. In all cases, the provisions of the Privacy Act Statement will be honored.
>
> b. I understand that a record of the information contained in this Consent Statement or derived from the experiment described herein will be retained permanently at the Naval Postgraduate School or by higher authority. I voluntarily agree to its disclosure to agencies or individuals indicated in paragraph 3 and I have been informed that failure to agree to such disclosure may negate the purpose for which the experiment was conducted.
>
> c. I also understand that disclosure of the requested information, including my Social Security Number, is voluntary.

____

Print Name /Signature of Volunteer, Rate/Rank (if applicable)

____

Date (SSN last four) (Date of Birth)

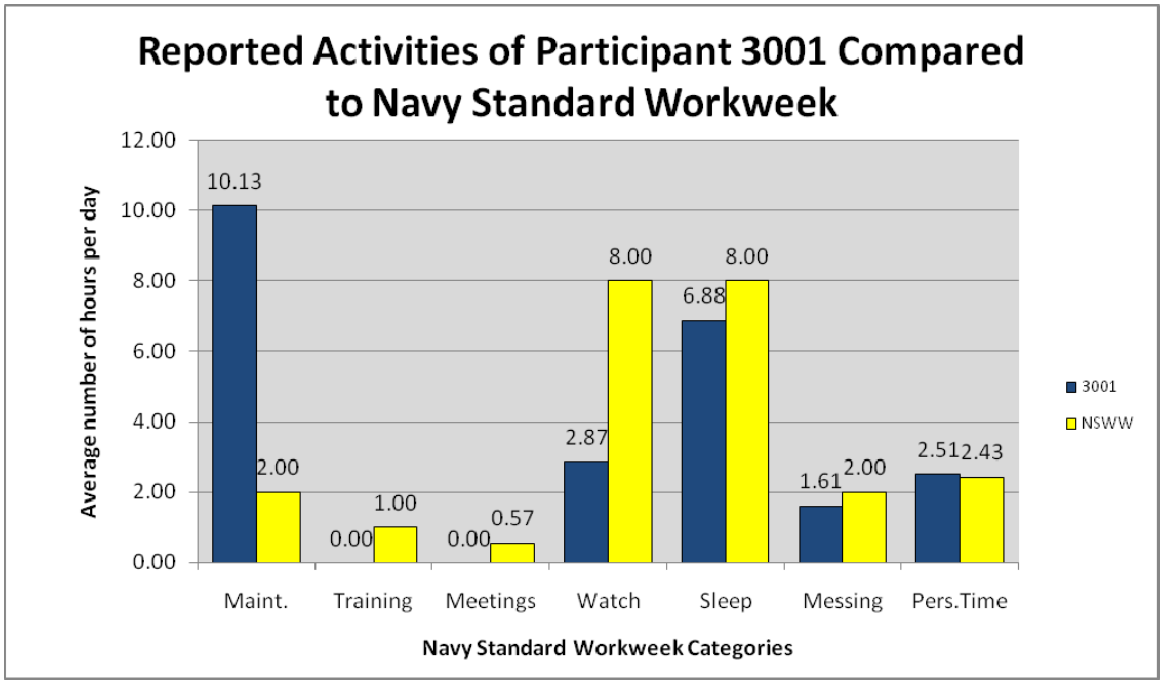
____

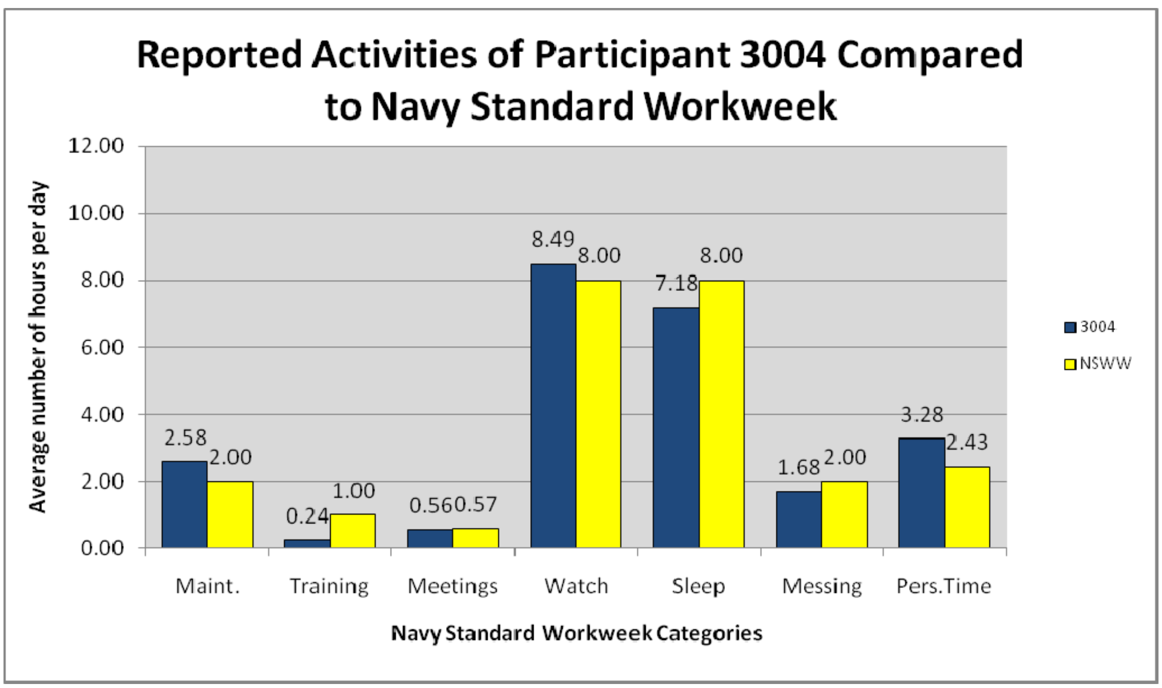
Participant ID# / Watch Serial Number

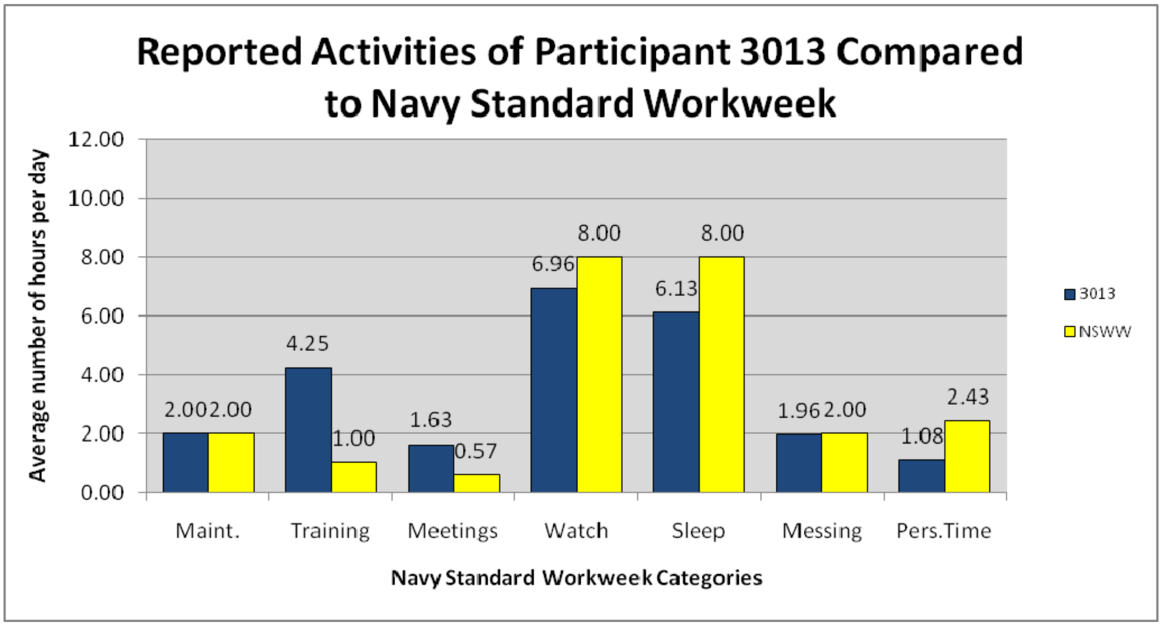
____

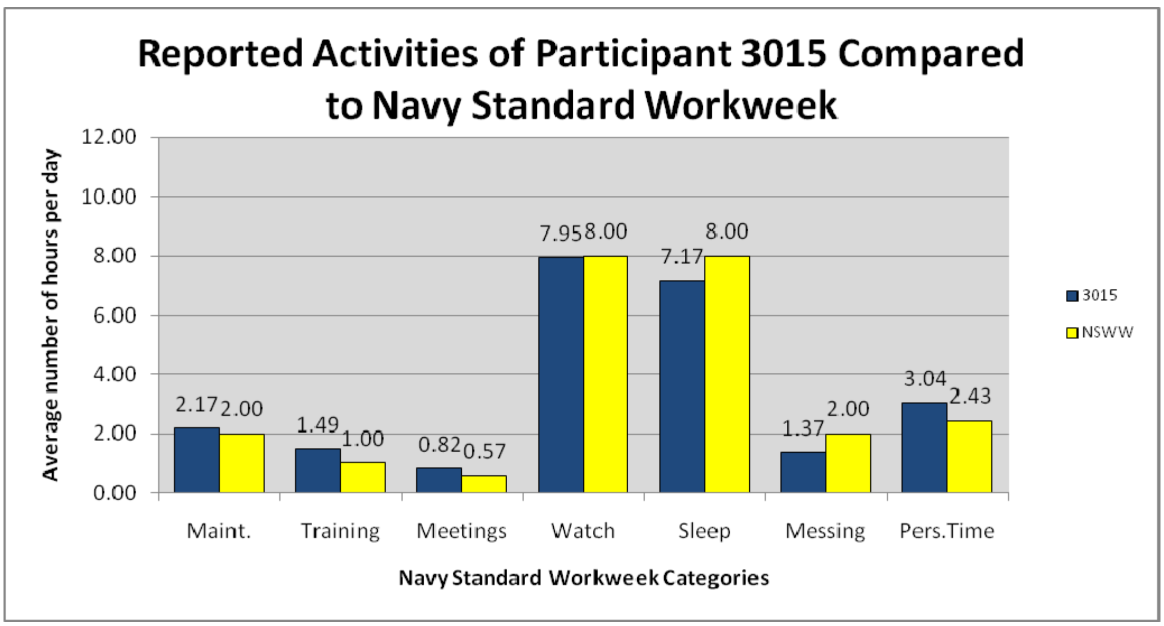
Signature of Witness/Date

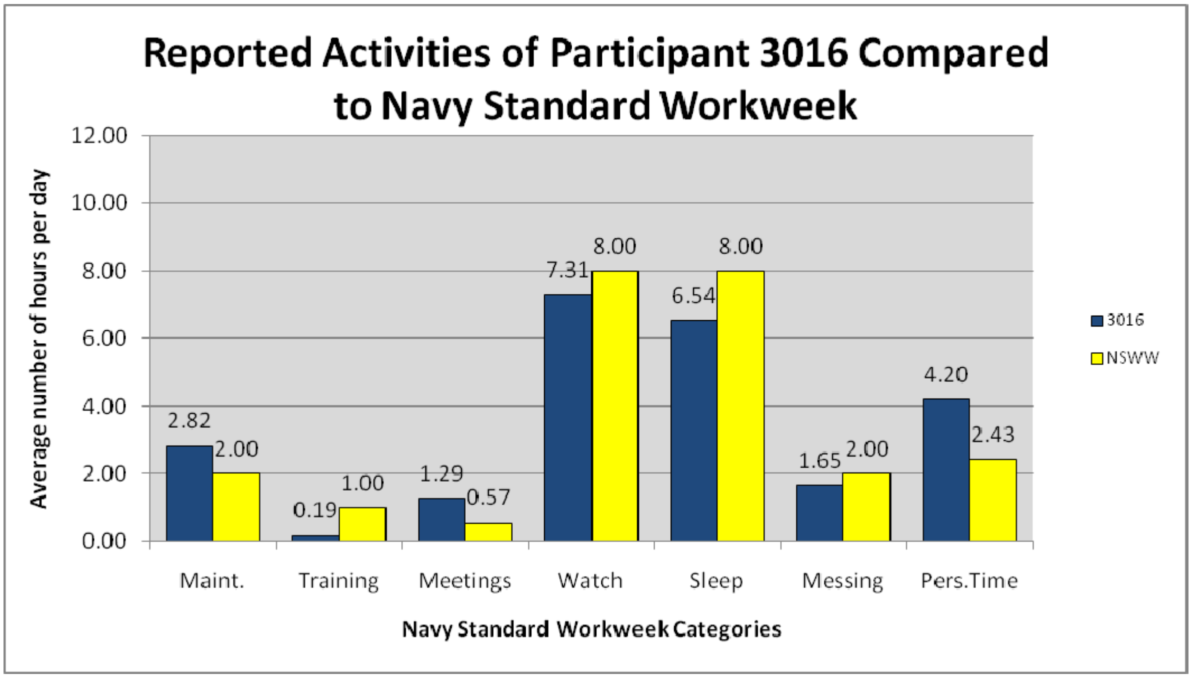
APPENDIX B. INDIVIDUAL SAILOR'S DAILY AVERAGE REPORTED AVAILABLE/NON-AVAILABLE TIME VS. NAVY STANDARD WORKWEEK BY CATEGORY



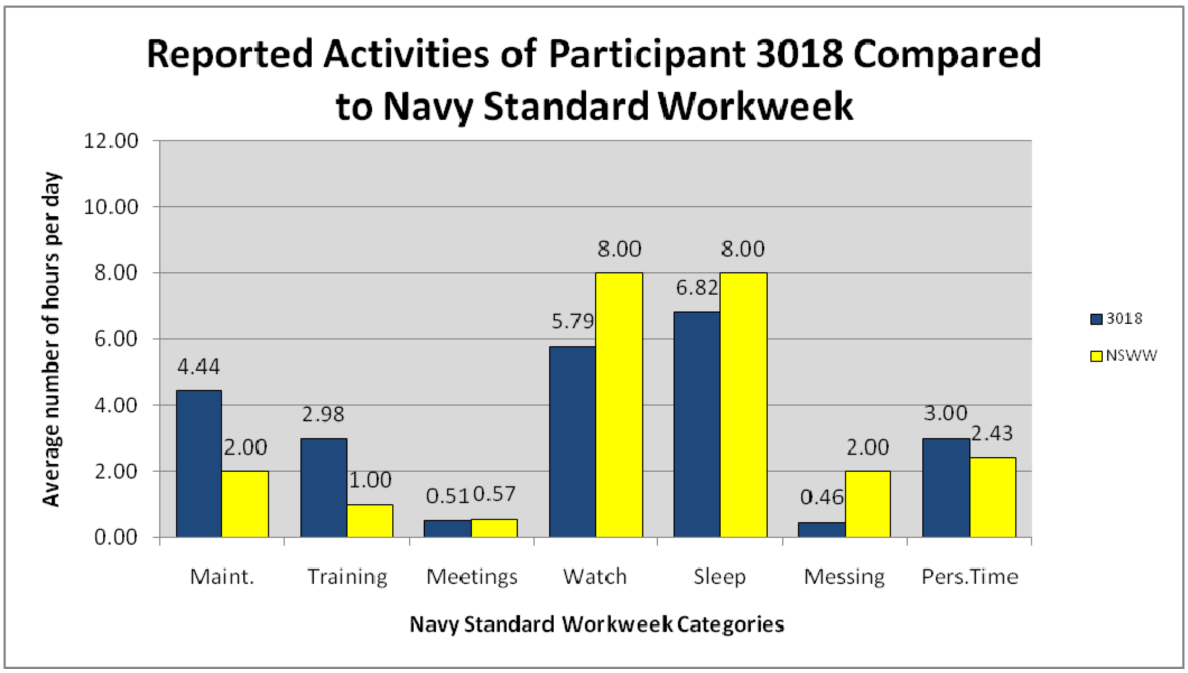



Reported Activities of Participant 3013 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2.00
2.00
4.25
1.00
1.63
0.57
6.96
8.00
6.13
8.00
1.96
2.00
1.08
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3013
NSWW

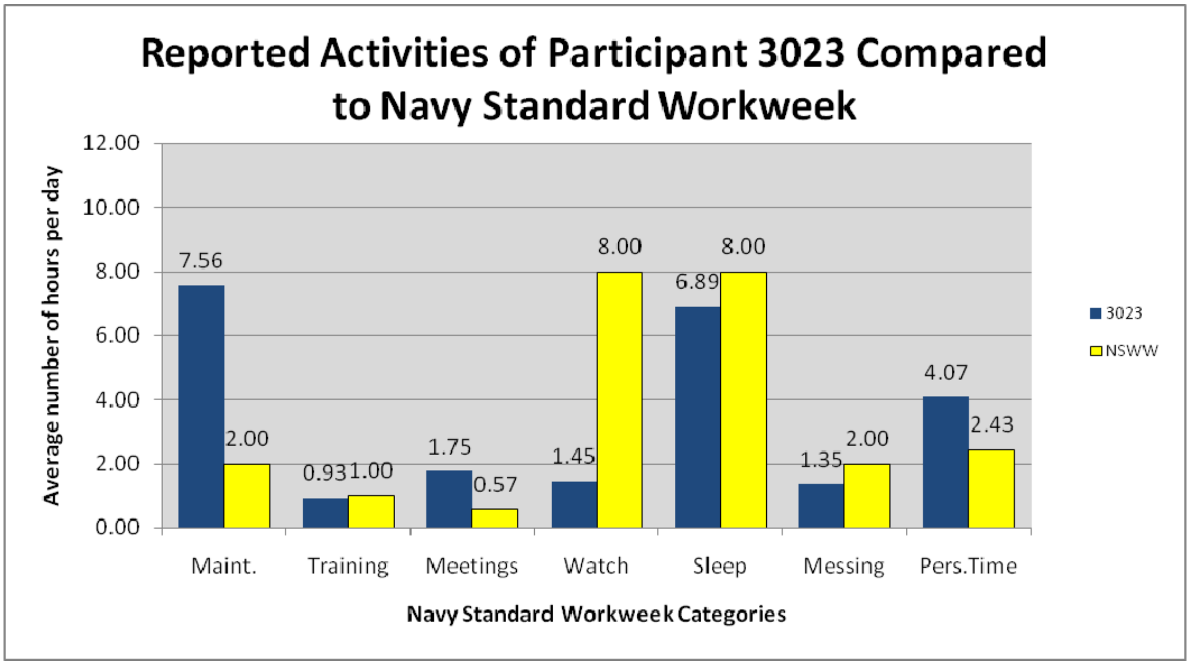

Reported Activities of Participant 3015 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2.17
2.00
1.49
1.00
0.82
0.57
7.95
8.00
7.17
8.00
1.37
2.00
3.04
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3015
NSWW

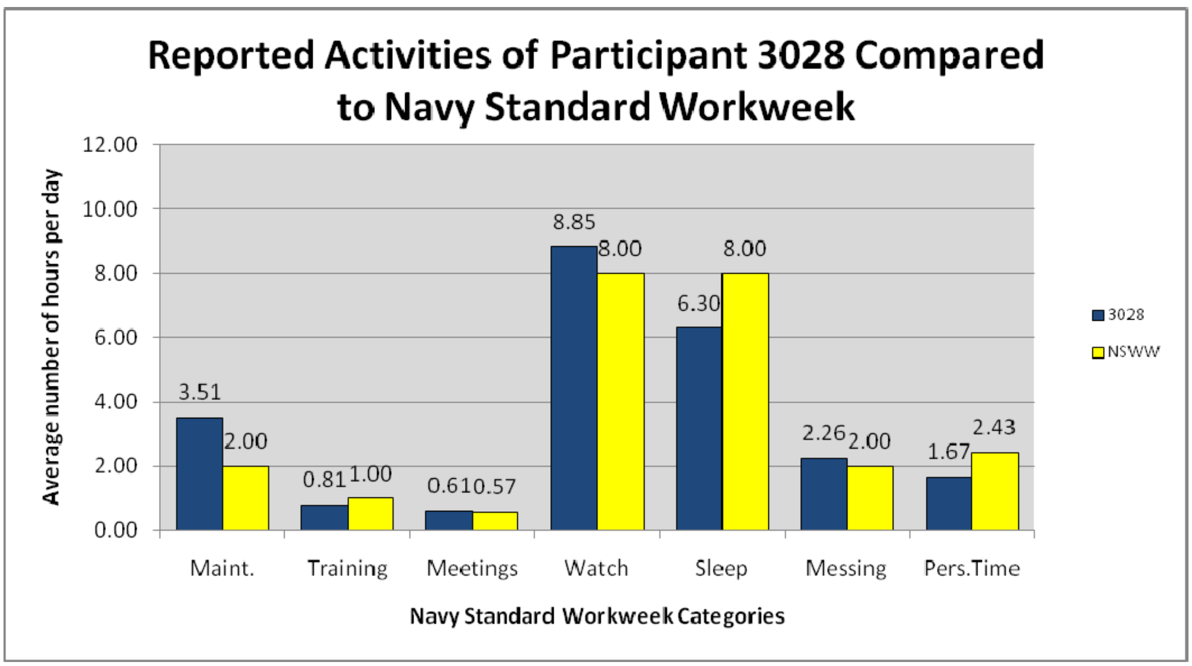


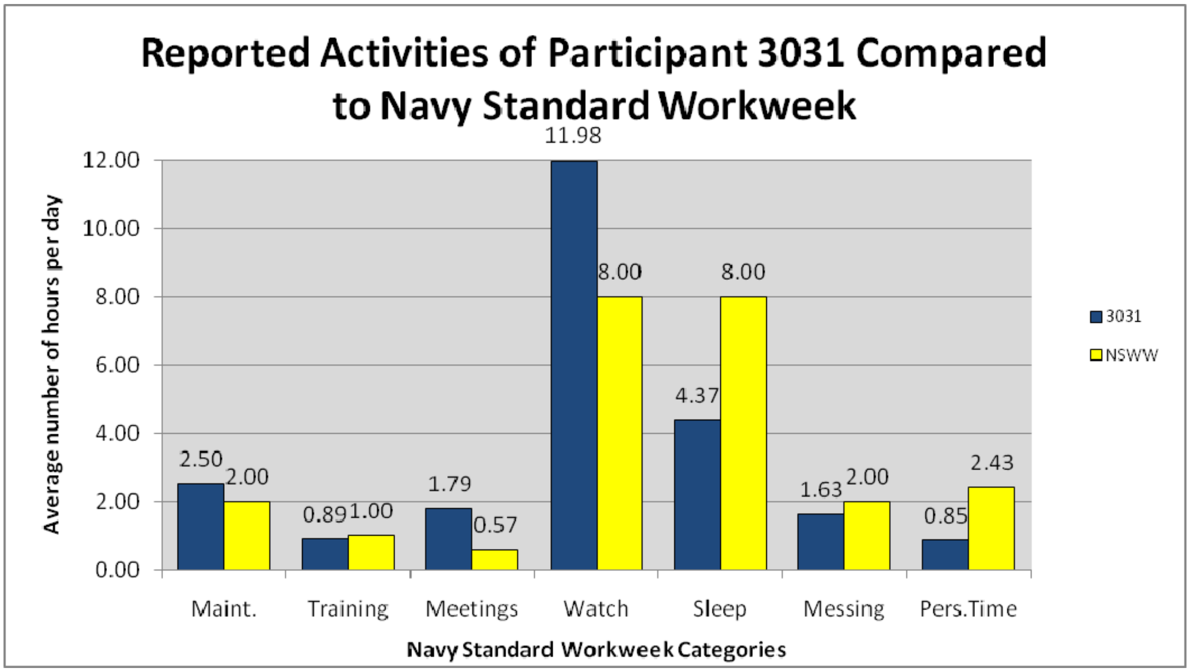
Reported Activities of Participant 3016 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2.82
2.00
0.19
1.00
1.29
0.57
7.31
8.00
6.54
8.00
1.65
2.00
4.20
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3016
NSWW

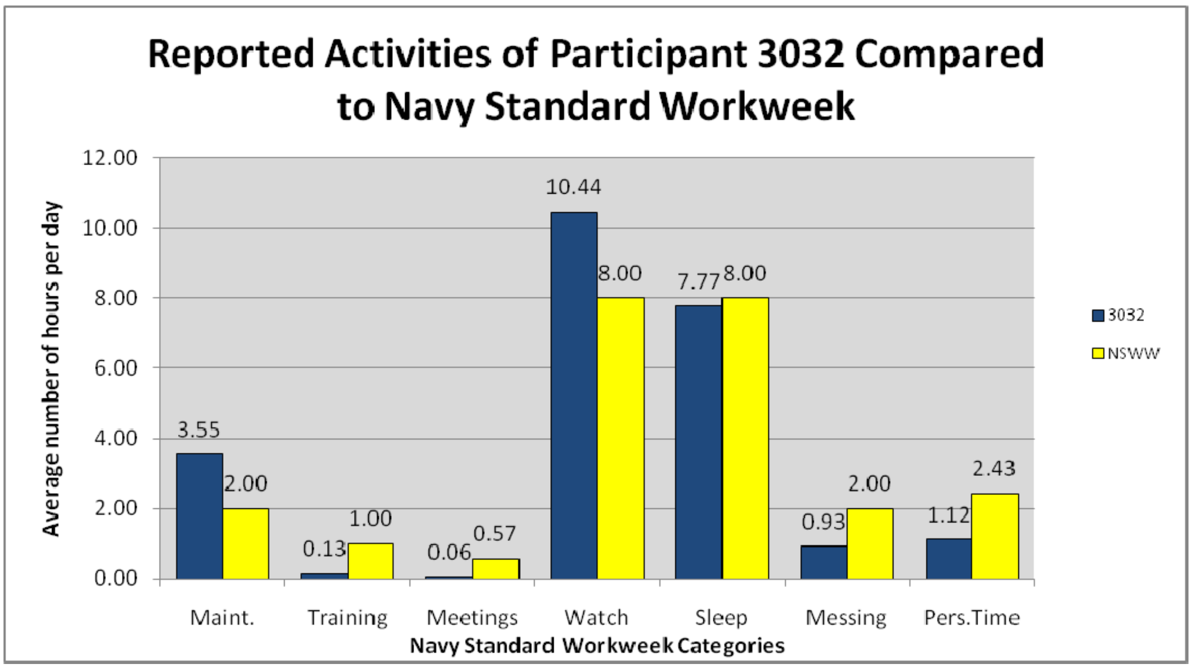


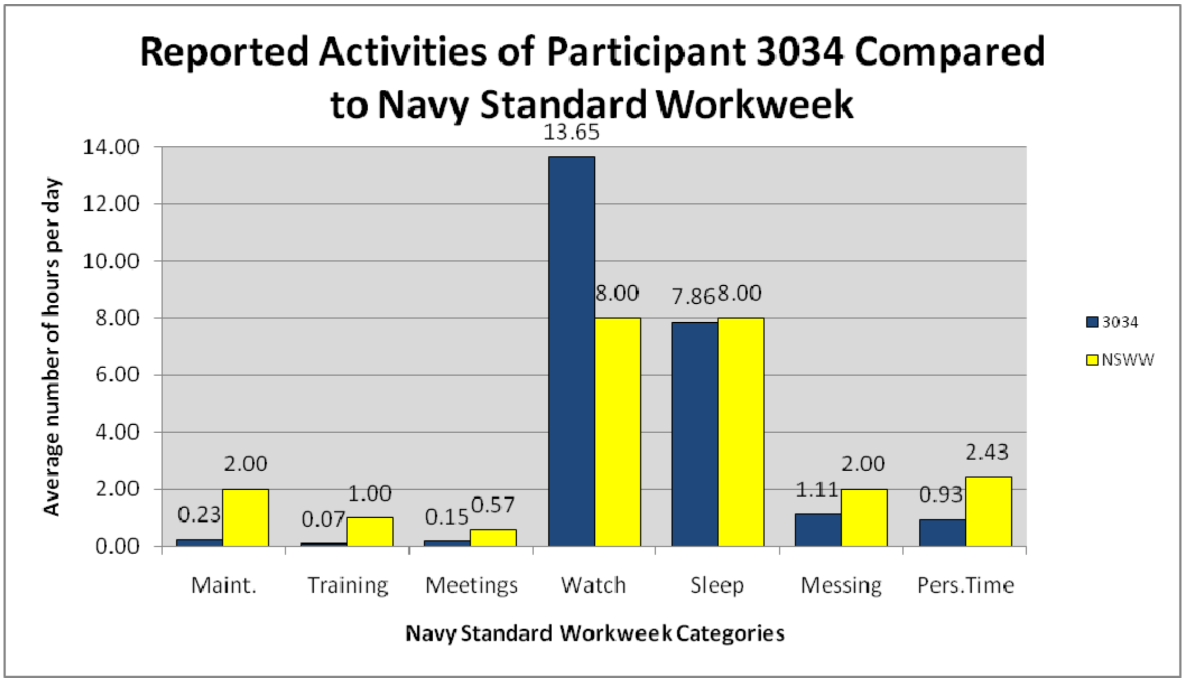
Reported Activities of Participant 3018 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4.44
2.00
2.98
1.00
0.51
0.57
5.79
8.00
6.82
8.00
0.46
2.00
3.00
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3018
NSWW

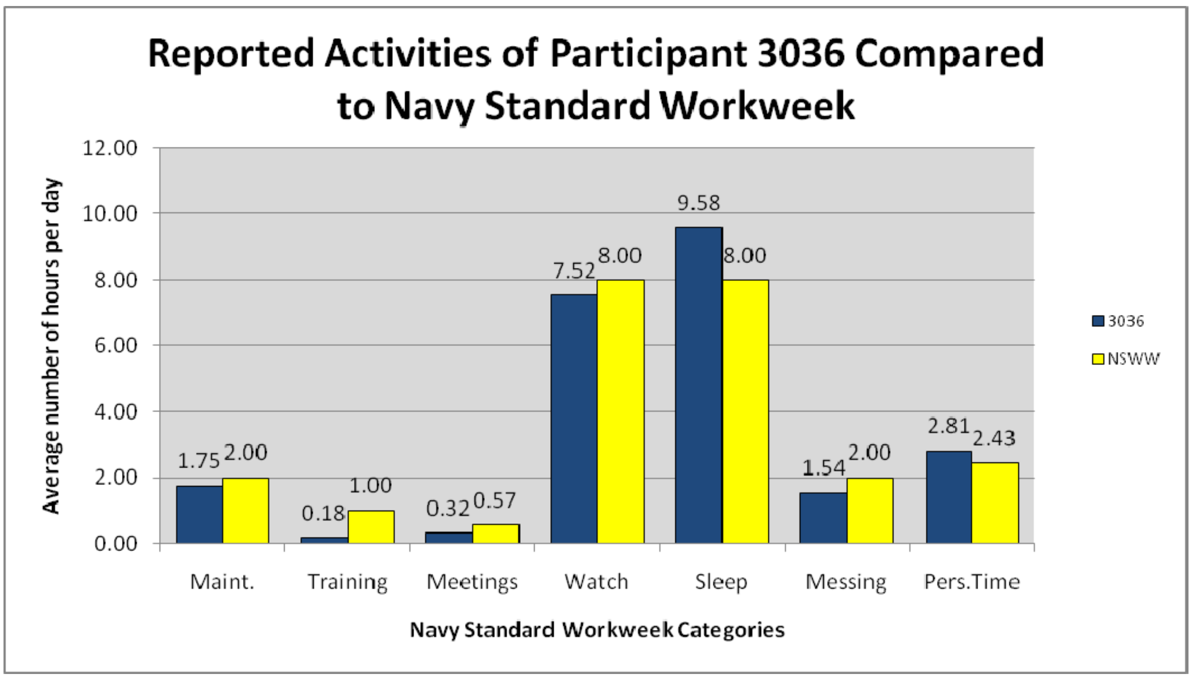

Reported Activities of Participant 3023 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
7.56
2.00
0.93
1.00
1.75
0.57
1.45
8.00
6.89
8.00
1.35
2.00
4.07
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3023
NSWW

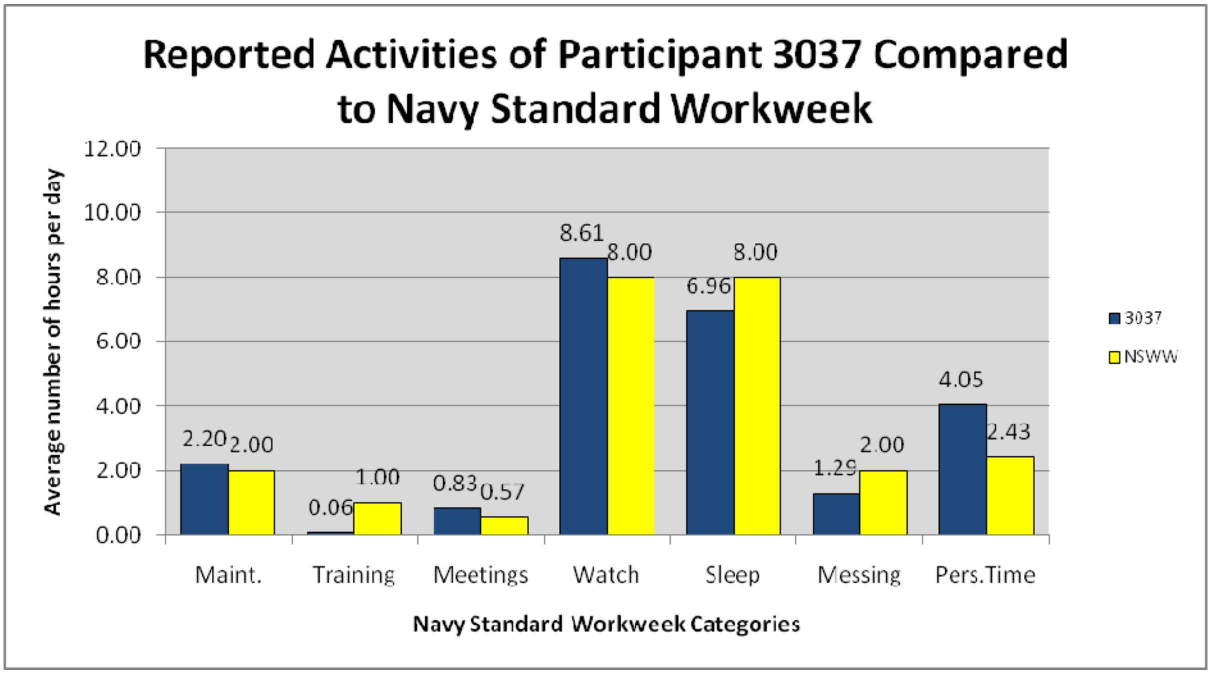

Reported Activities of Participant 3028 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
3.51
2.00
0.81
1.00
0.61
0.57
8.85
8.00
6.30
8.00
2.26
2.00
1.67
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3028
NSWW

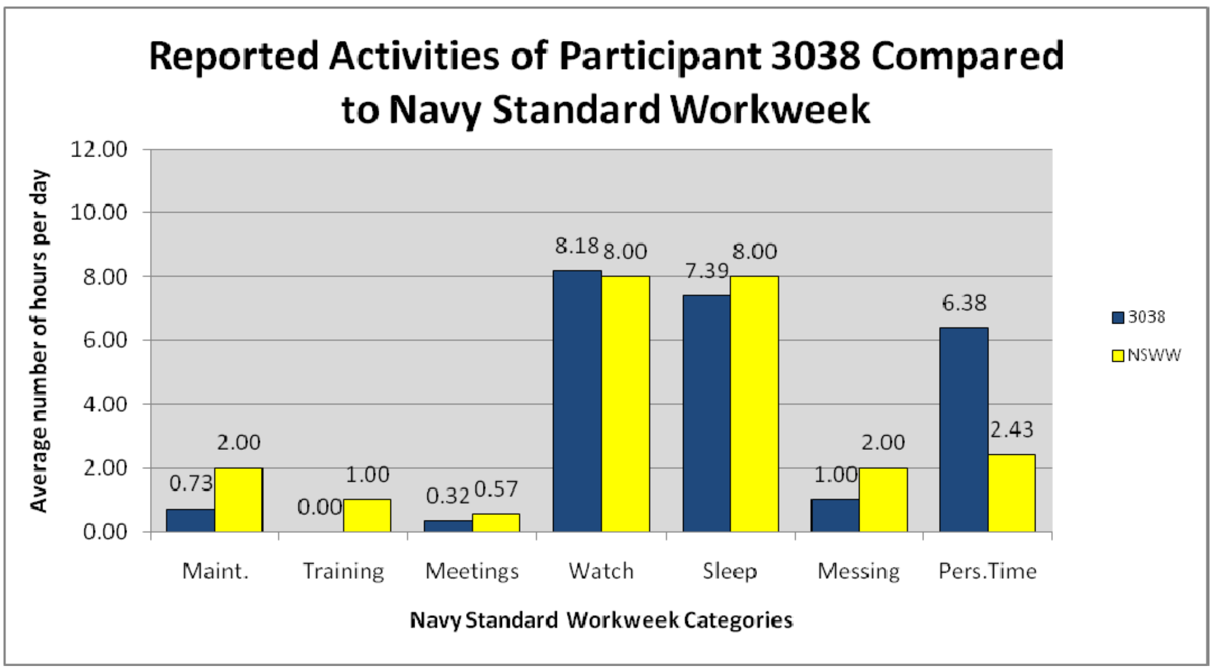

Reported Activities of Participant 3031 Compared to Navy Standard Workweek
Average number of hours per day
Navy Standard Workweek Categories
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
3031
NSWW
2.50
2.00
0.89
1.00
1.79
0.57
11.98
8.00
4.37
8.00
1.63
2.00
0.85
2.43

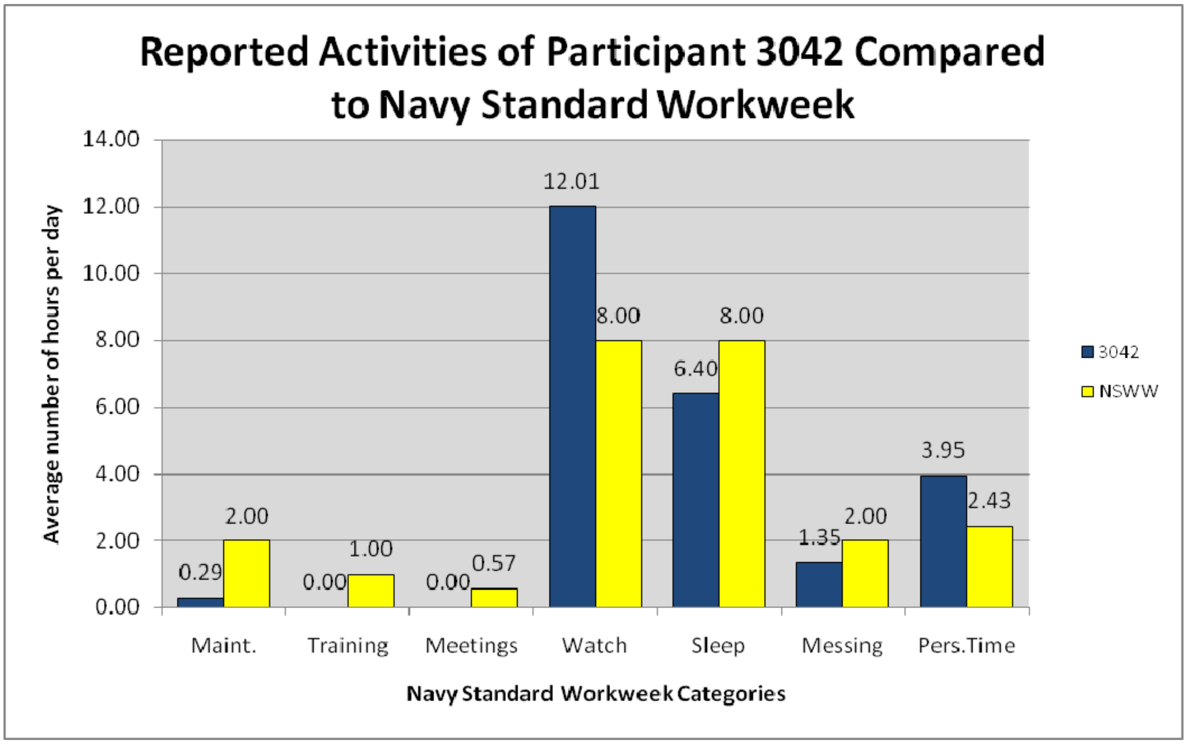

Reported Activities of Participant 3032 Compared to Navy Standard Workweek
Average number of hours per day
Navy Standard Workweek Categories
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
3032
NSWW
3.55
2.00
0.13
1.00
0.06
0.57
10.44
8.00
7.77
8.00
0.93
2.00
1.12
2.43

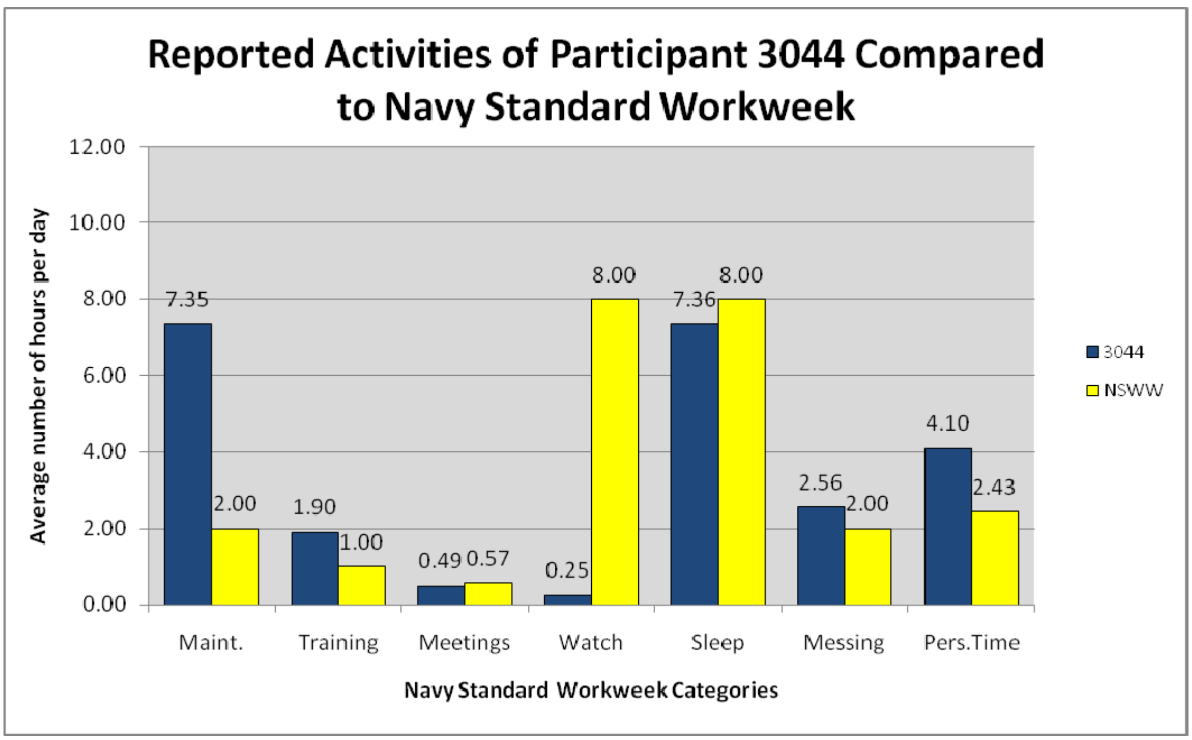

Reported Activities of Participant 3034 Compared to Navy Standard Workweek
Average number of hours per day
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.23
2.00
0.07
1.00
0.15
0.57
13.65
8.00
7.86
8.00
1.11
2.00
0.93
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3034
NSWW

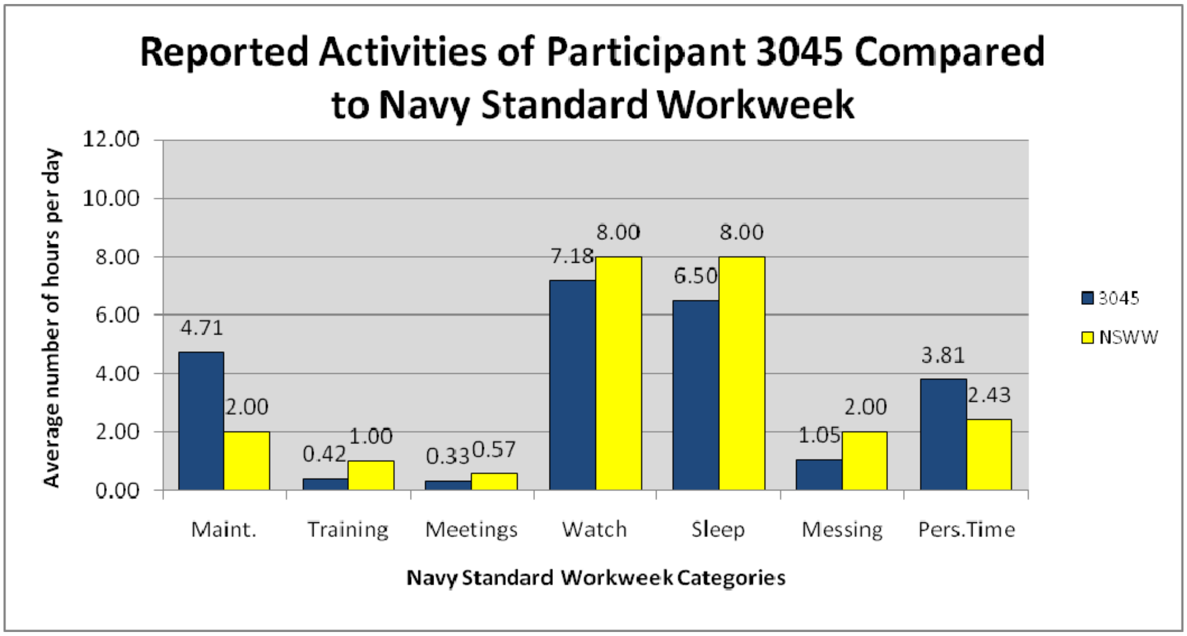

Reported Activities of Participant 3036 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1.75
2.00
0.18
1.00
0.32
0.57
7.52
8.00
9.58
8.00
1.54
2.00
2.81
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3036
NSWW

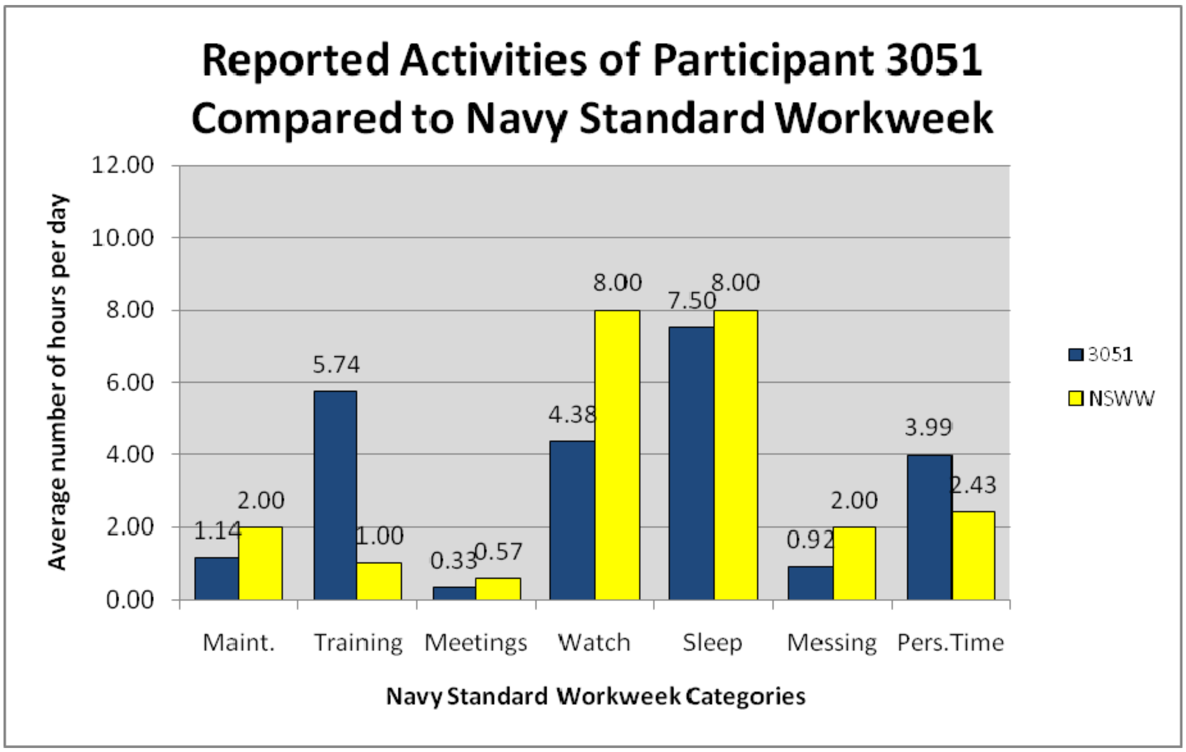

Reported Activities of Participant 3037 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2.20
2.00
0.06
1.00
0.83
0.57
8.61
8.00
6.96
8.00
1.29
2.00
4.05
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3037
NSWW

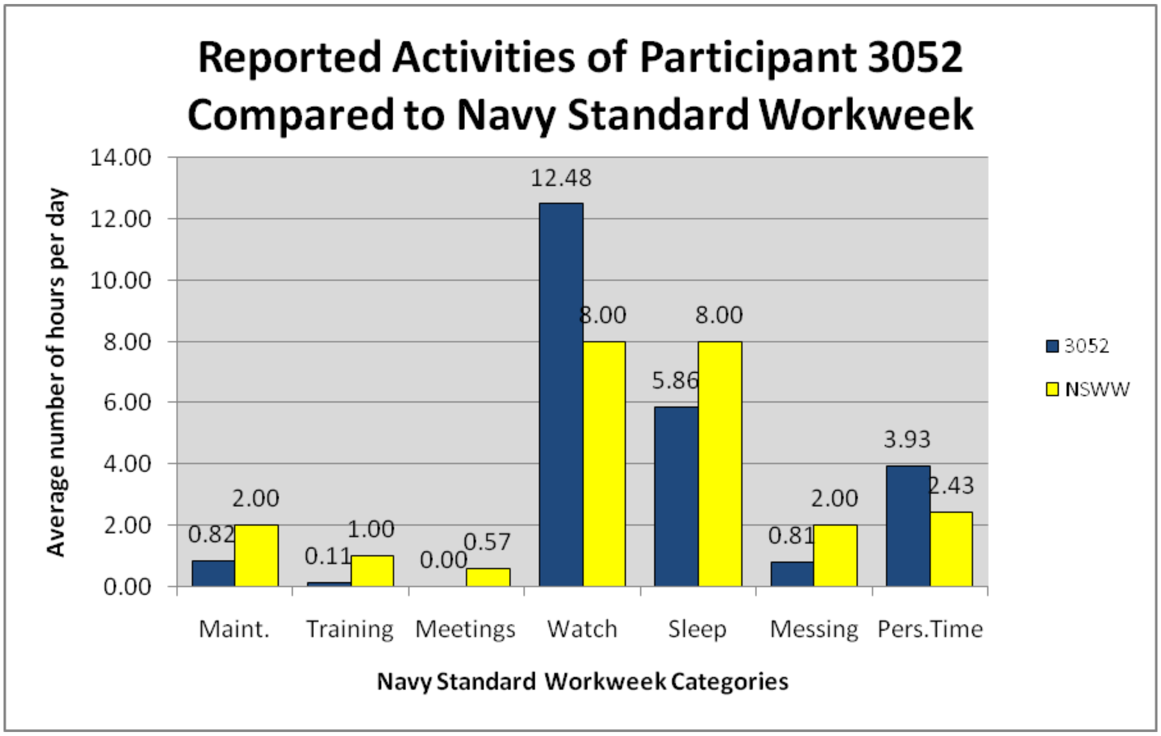

Reported Activities of Participant 3038 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.73
2.00
0.00
1.00
0.32
0.57
8.18
8.00
7.39
8.00
1.00
2.00
6.38
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3038
NSWW

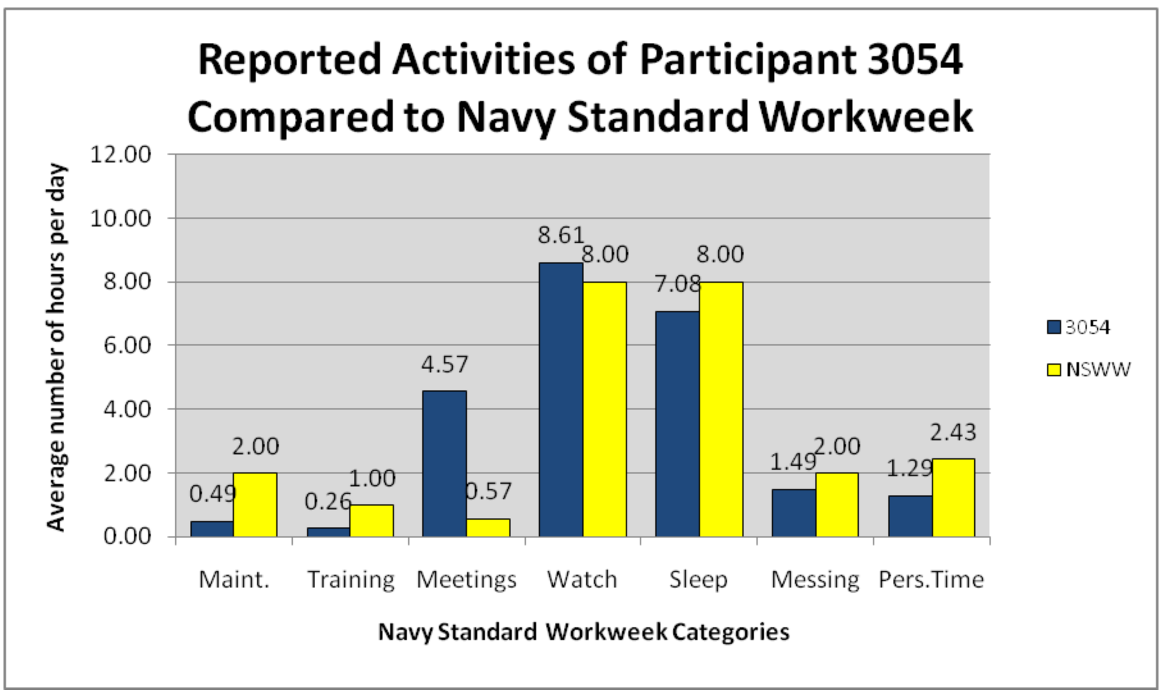

Reported Activities of Participant 3042 Compared to Navy Standard Workweek
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Average number of hours per day
0.29
2.00
0.00
1.00
0.00
0.57
12.01
8.00
6.40
8.00
1.35
2.00
3.95
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3042
NSWW

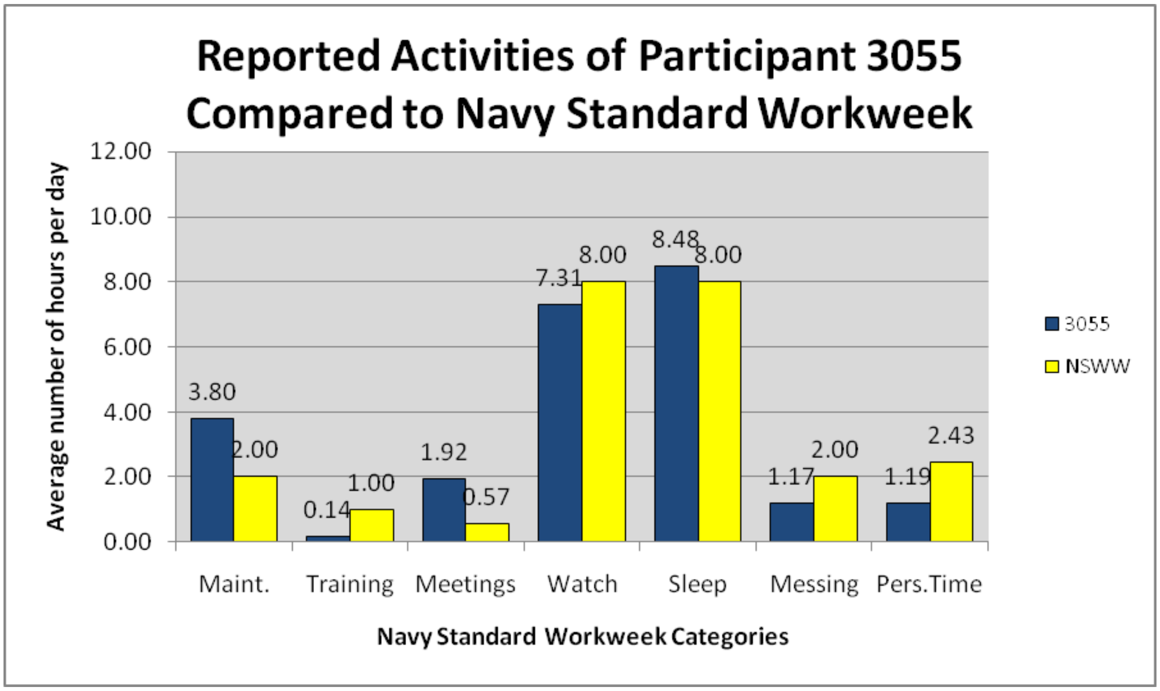

Reported Activities of Participant 3044 Compared to Navy Standard Workweek
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Average number of hours per day
7.35
2.00
1.90
1.00
0.49
0.57
0.25
8.00
7.36
8.00
2.56
2.00
4.10
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3044
NSWW

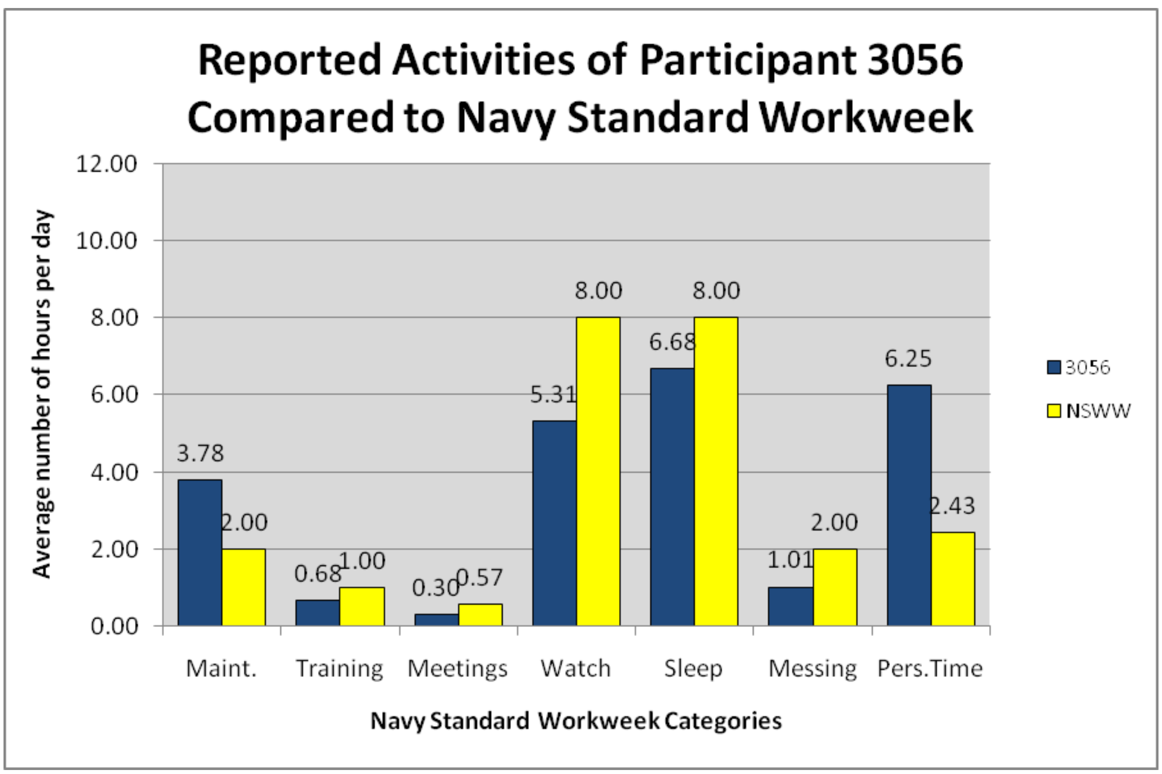

Reported Activities of Participant 3045 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4.71
2.00
0.42
1.00
0.33
0.57
7.18
8.00
6.50
8.00
1.05
2.00
3.81
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3045
NSWW

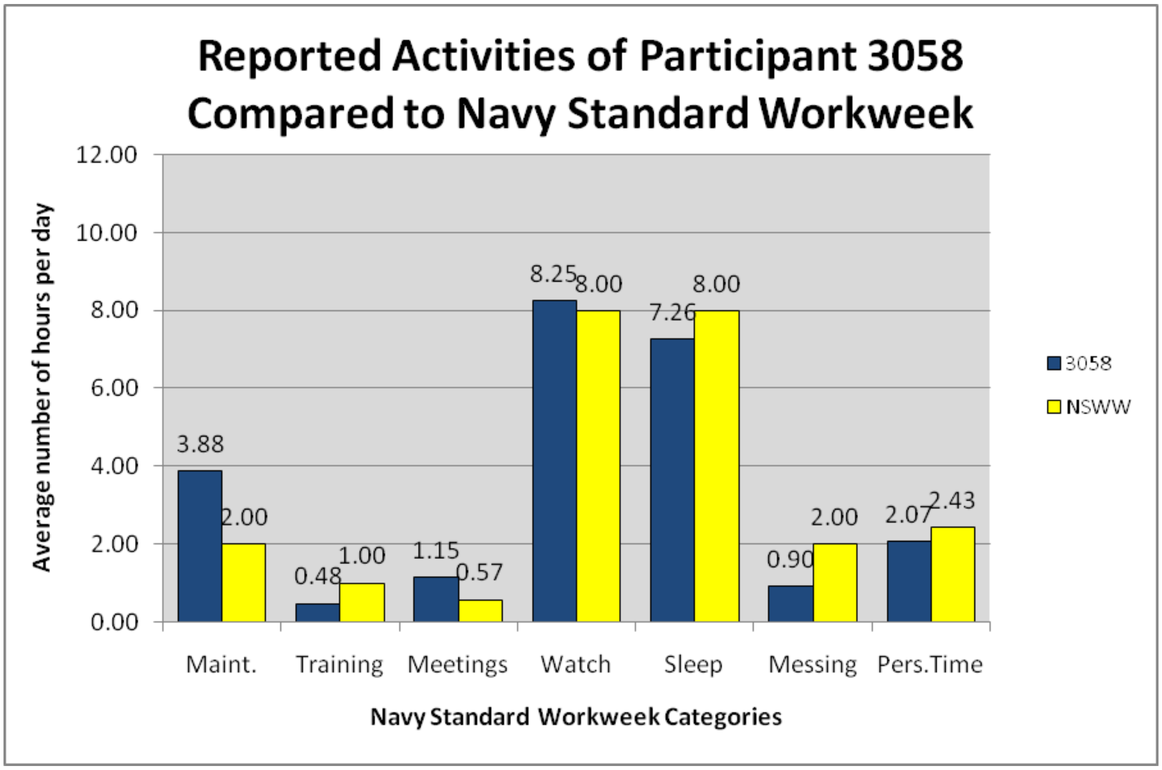

Reported Activities of Participant 3051 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1.14
2.00
5.74
1.00
0.33
0.57
4.38
8.00
7.50
8.00
0.92
2.00
3.99
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3051
NSWW

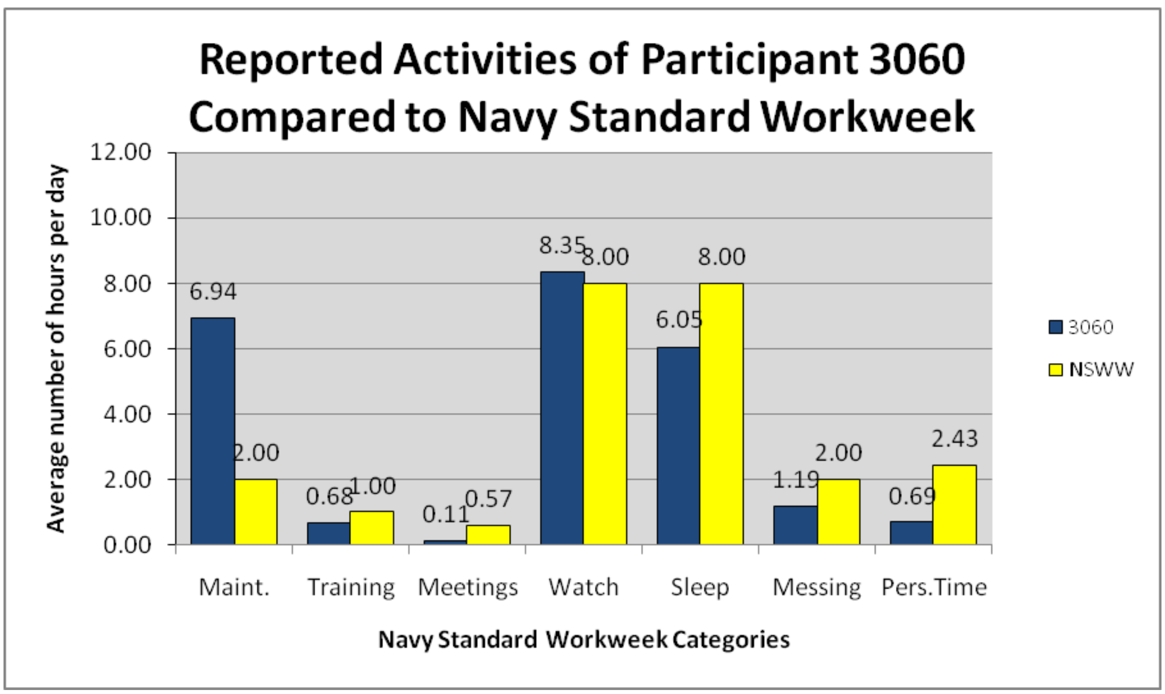

Reported Activities of Participant 3052
Compared to Navy Standard Workweek
Average number of hours per day
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
12.48
8.00
8.00
5.86
3.93
2.43
2.00
2.00
0.82
1.00
0.11
0.00
0.57
0.81
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3052
NSWW

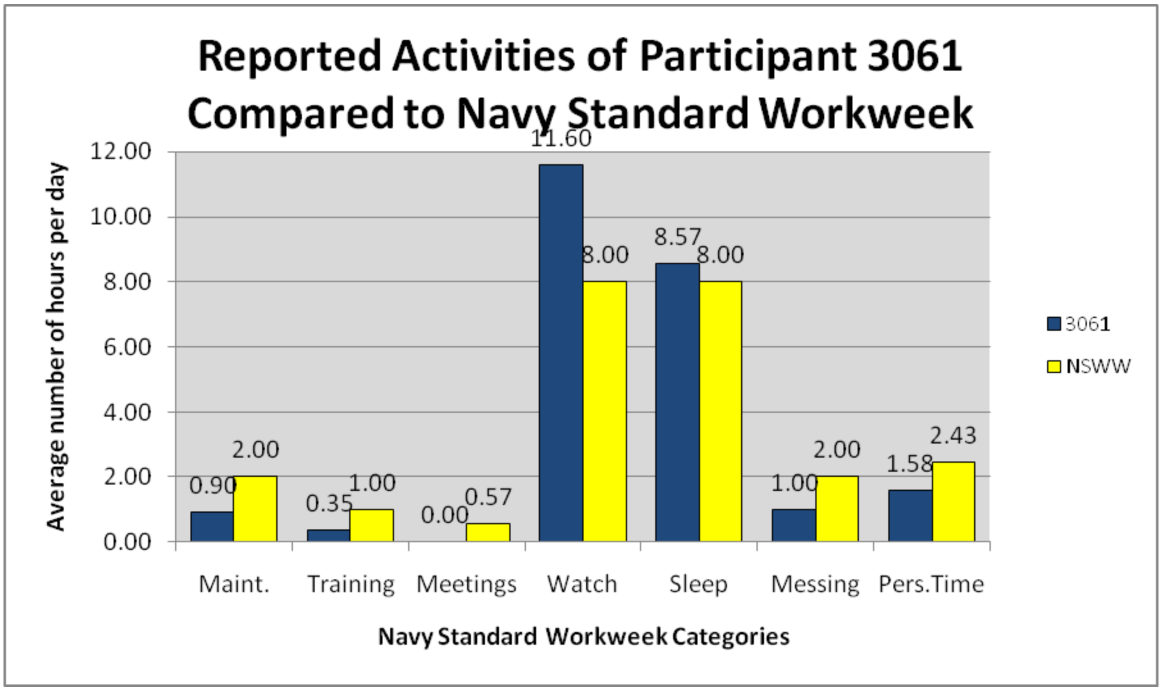

Reported Activities of Participant 3054
Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
8.61
8.00
8.00
7.08
4.57
2.00
0.49
1.00
0.26
0.57
1.49
2.00
1.29
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3054
NSWW

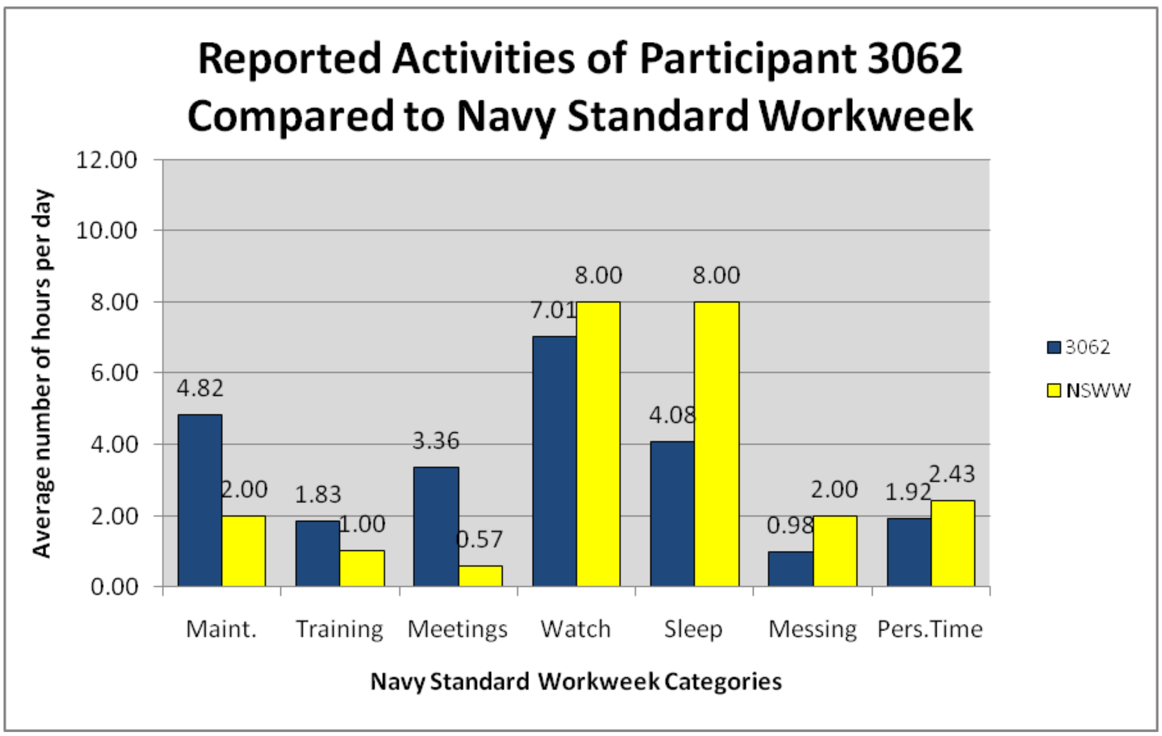

Reported Activities of Participant 3055
Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
3.80
2.00
0.14
1.00
1.92
0.57
7.31
8.00
8.48
8.00
1.17
2.00
1.19
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3055
NSWW

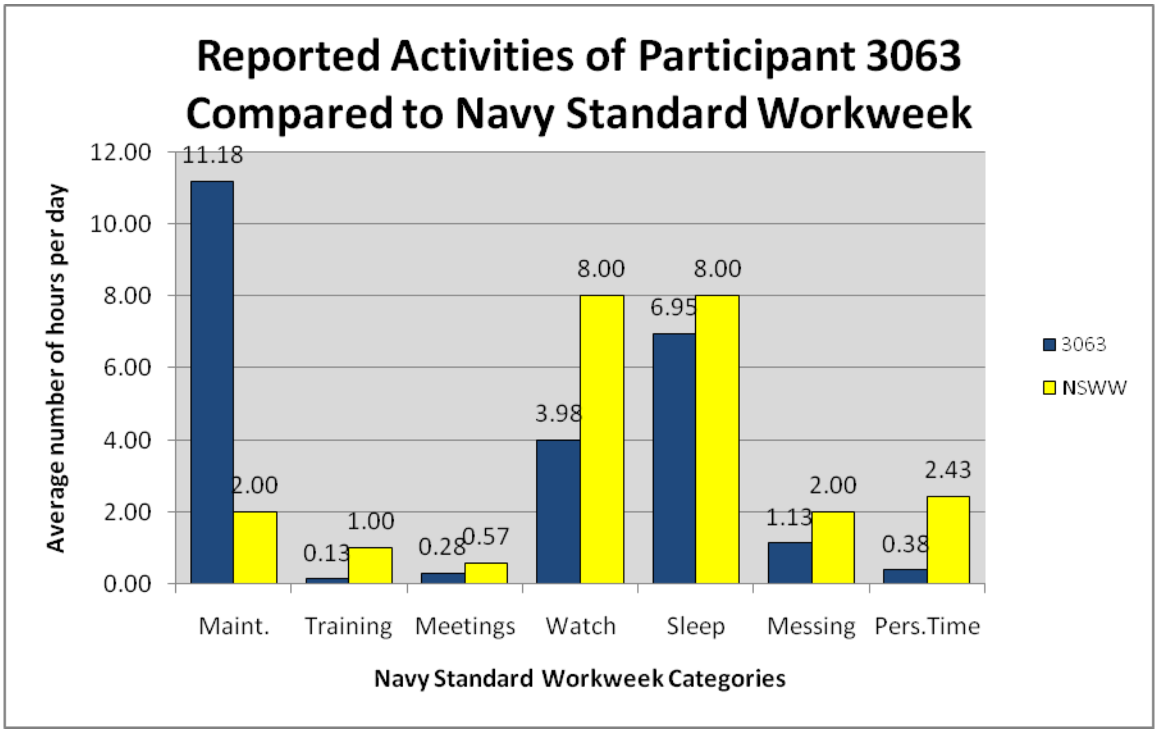

Reported Activities of Participant 3056
Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
3.78
2.00
0.68
1.00
0.30
0.57
5.31
8.00
6.68
8.00
1.01
2.00
6.25
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3056
NSWW

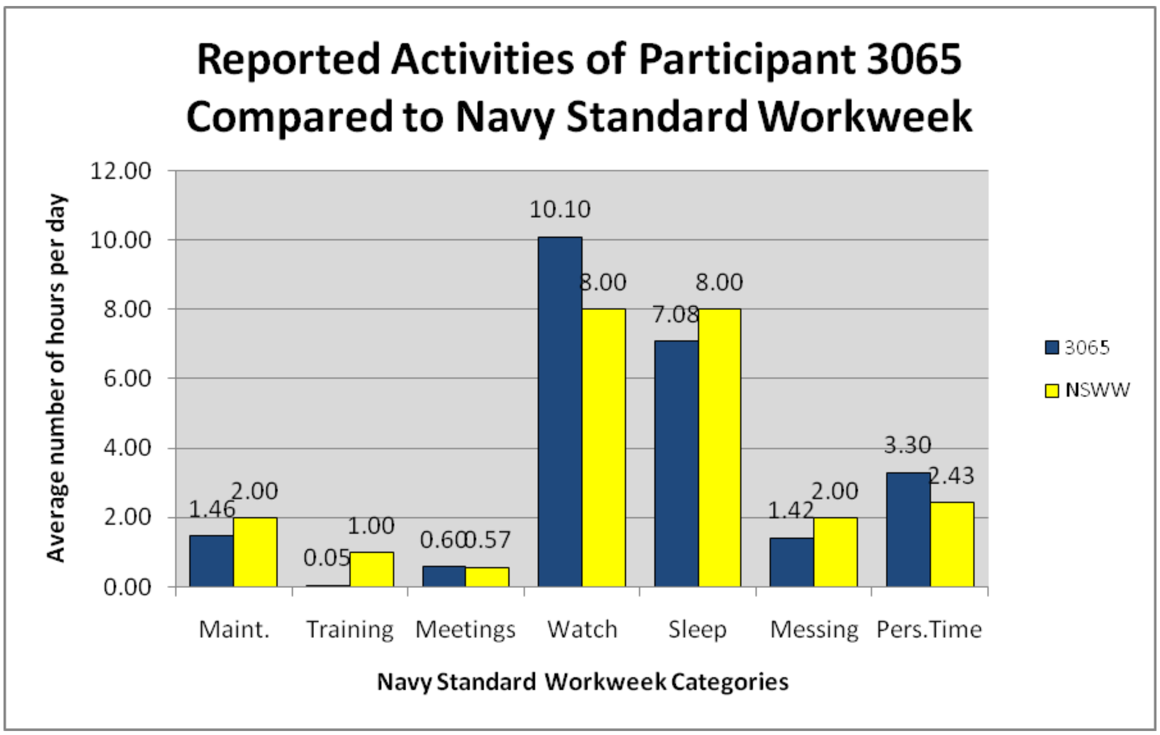

Reported Activities of Participant 3058 Compared to Navy Standard Workweek
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Average number of hours per day
3.88
2.00
0.48
1.00
1.15
0.57
8.25
8.00
7.26
8.00
0.90
2.00
2.07
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3058
NSWW

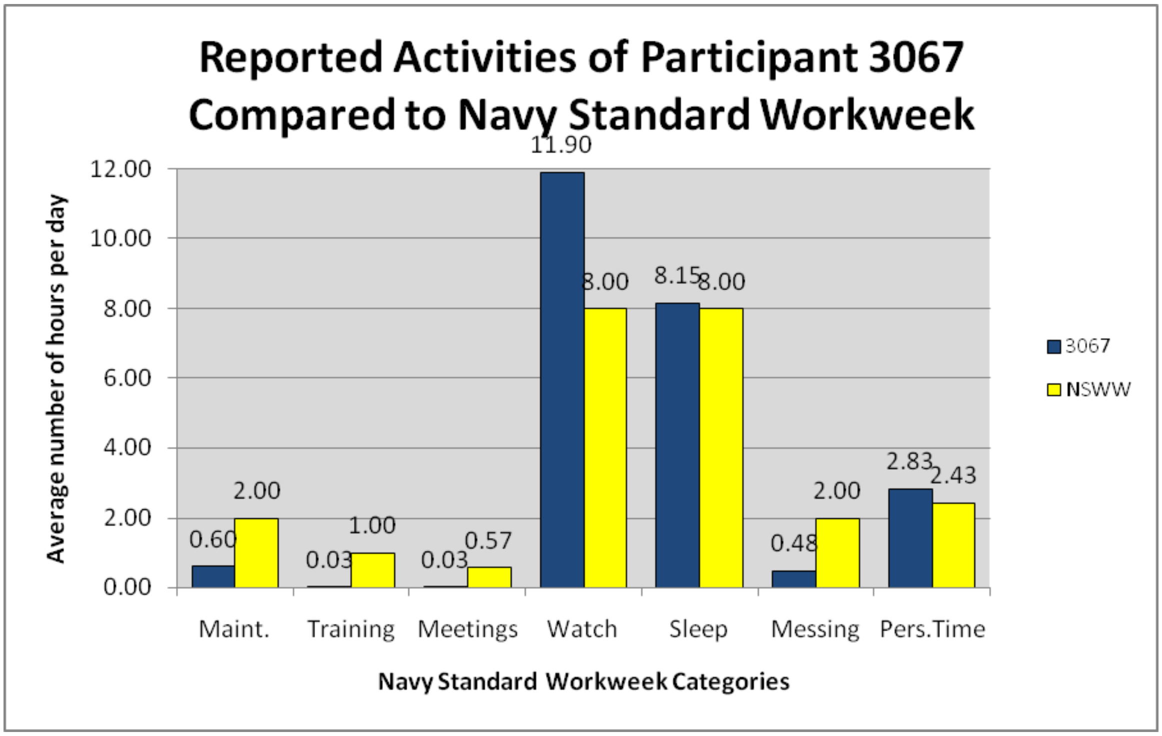

Reported Activities of Participant 3060 Compared to Navy Standard Workweek
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Average number of hours per day
6.94
2.00
0.68
1.00
0.11
0.57
8.35
8.00
6.05
8.00
1.19
2.00
0.69
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3060
NSWW

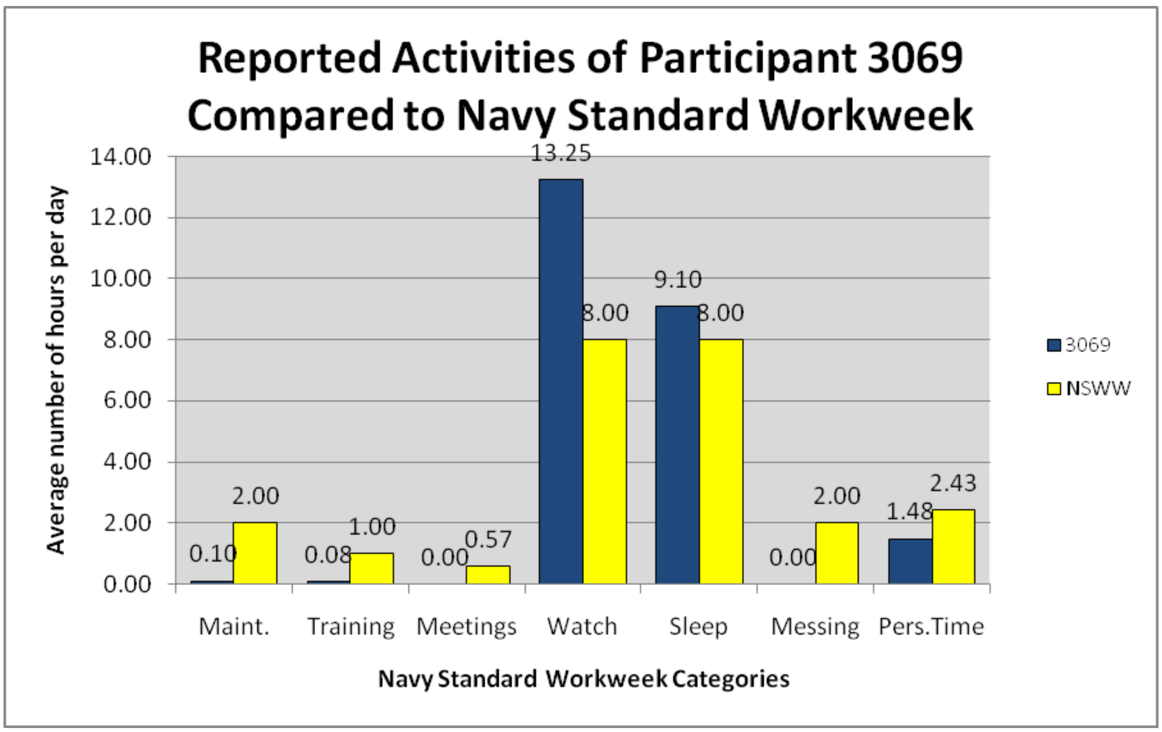

Reported Activities of Participant 3061 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.90
2.00
0.35
1.00
0.00
0.57
11.60
8.00
8.57
8.00
1.00
2.00
1.58
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3061
NSWW

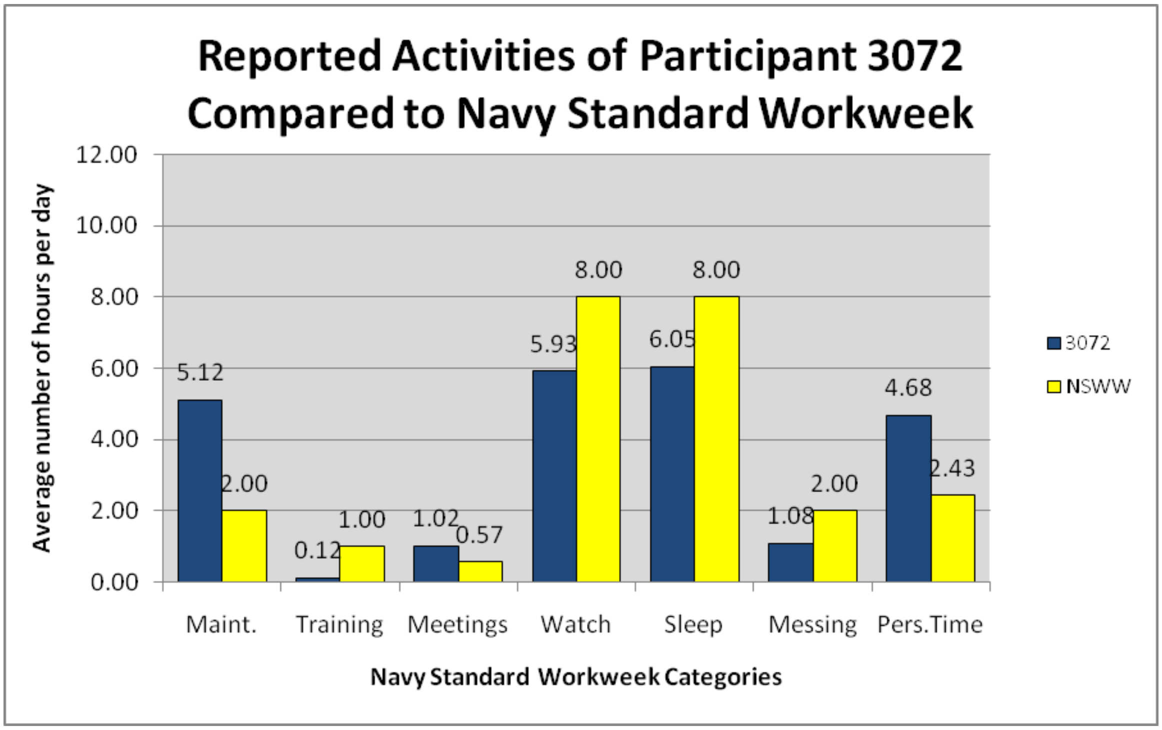

Reported Activities of Participant 3062 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4.82
2.00
1.83
1.00
3.36
0.57
7.01
8.00
4.08
8.00
0.98
2.00
1.92
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3062
NSWW

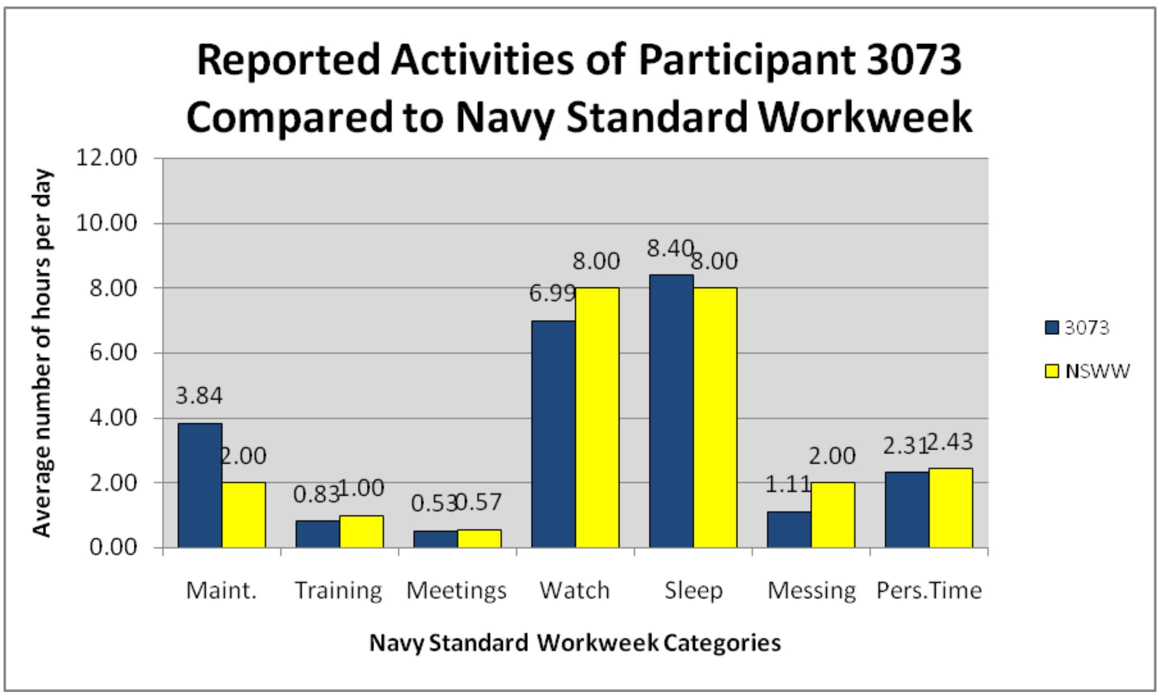

Reported Activities of Participant 3063 Compared to Navy Standard Workweek
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Average number of hours per day
11.18
2.00
0.13
1.00
0.28
0.57
3.98
8.00
6.95
8.00
1.13
2.00
0.38
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3063
NSWW

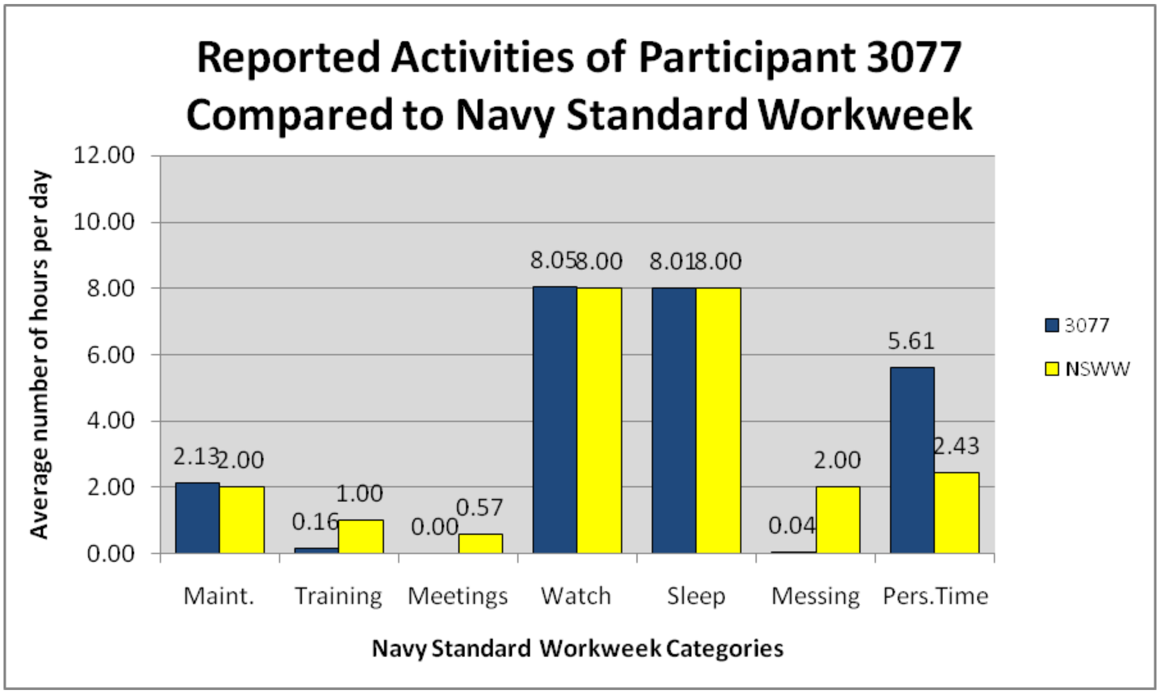

Reported Activities of Participant 3065 Compared to Navy Standard Workweek
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Average number of hours per day
1.46
2.00
0.05
1.00
0.60
0.57
10.10
8.00
7.08
8.00
1.42
2.00
3.30
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3065
NSWW

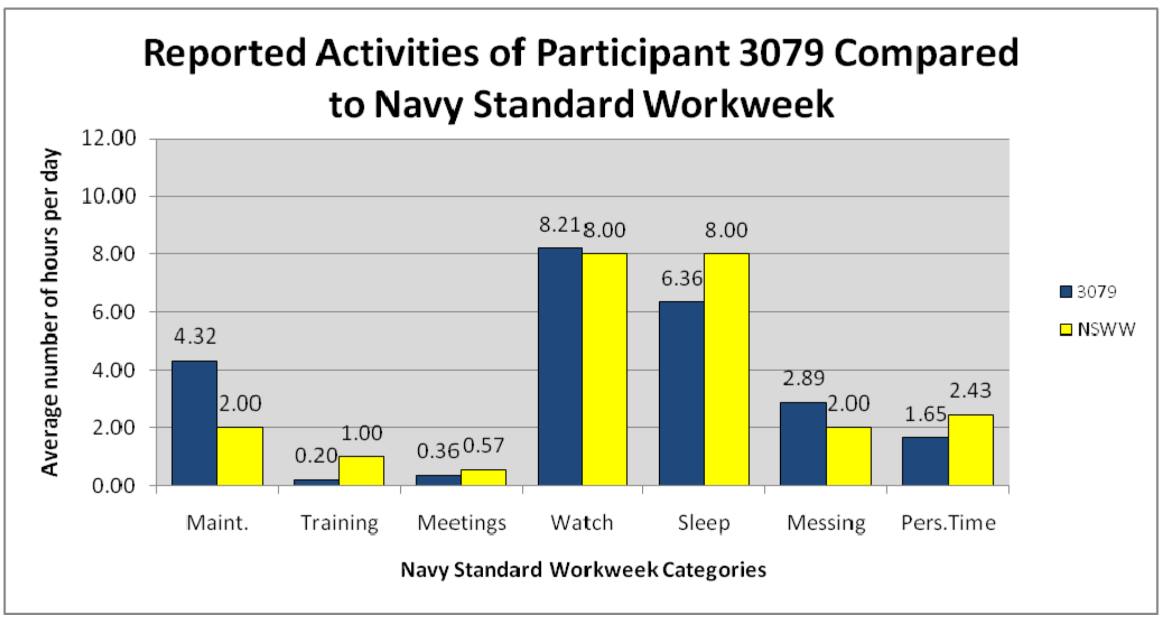

Reported Activities of Participant 3067
Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.60
2.00
0.03
1.00
0.03
0.57
11.90
8.00
8.15
8.00
0.48
2.00
2.83
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3067
NSWW

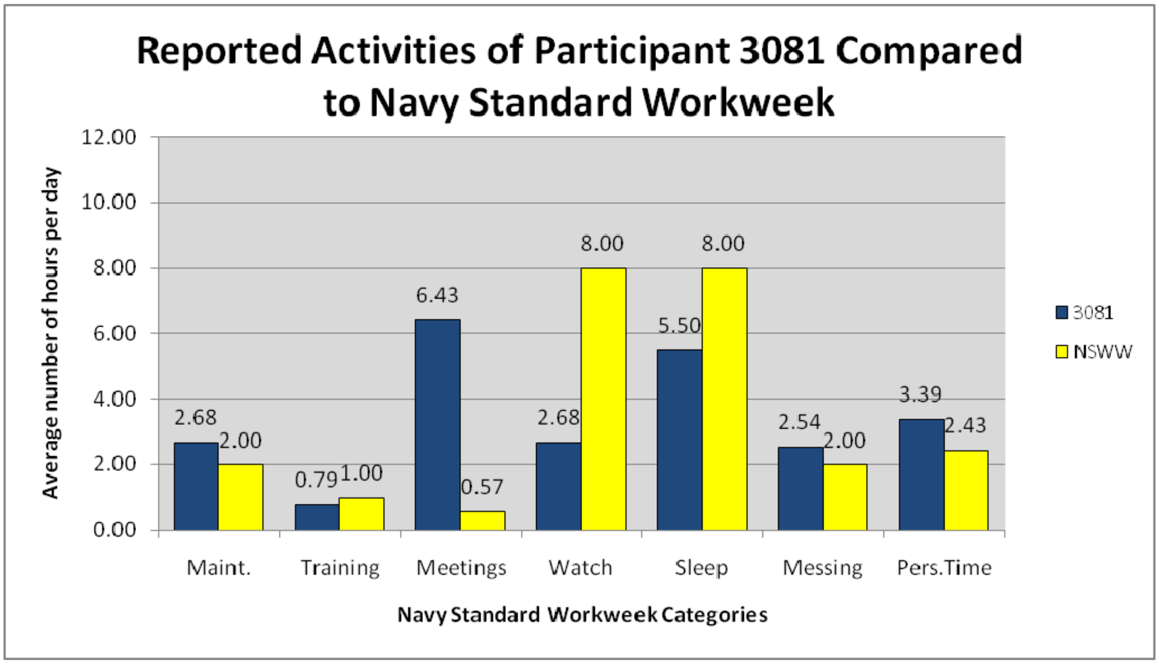

Reported Activities of Participant 3069
Compared to Navy Standard Workweek
Average number of hours per day
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.10
2.00
0.08
1.00
0.00
0.57
13.25
8.00
9.10
8.00
0.00
2.00
1.48
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3069
NSWW


Reported Activities of Participant 3072
Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
5.12
2.00
0.12
1.00
1.02
0.57
5.93
8.00
6.05
8.00
1.08
2.00
4.68
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3072
NSWW

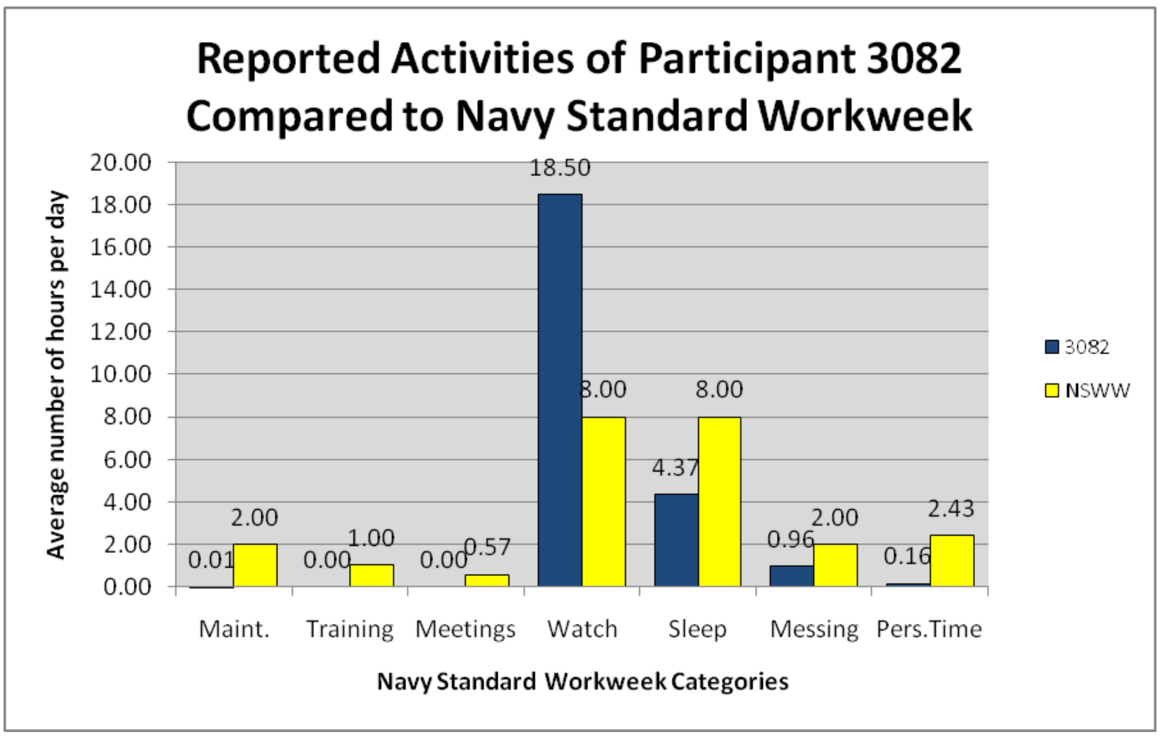

Reported Activities of Participant 3073
Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
3.84
2.00
0.83
1.00
0.53
0.57
6.99
8.00
8.40
8.00
1.11
2.00
2.31
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3073
NSWW


Reported Activities of Participant 3077 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2.13
2.00
0.16
1.00
0.00
0.57
8.05
8.00
8.01
8.00
0.04
2.00
5.61
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3077
NSWW

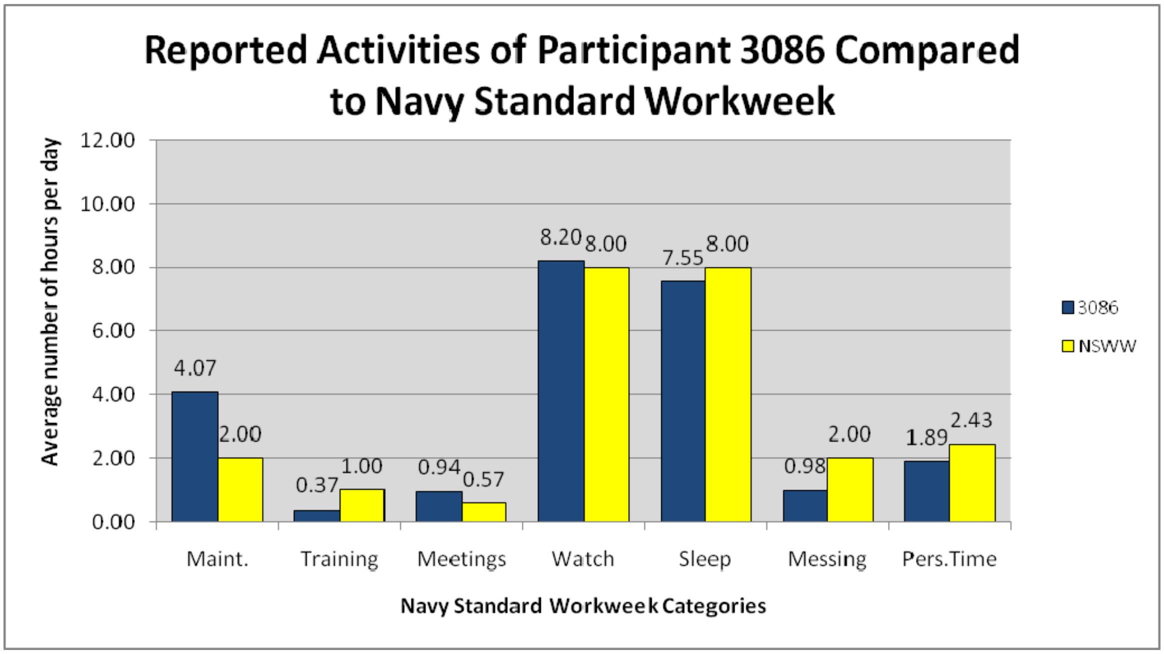

Reported Activities of Participant 3079 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4.32
2.00
0.20
1.00
0.36
0.57
8.21
8.00
6.36
8.00
2.89
2.00
1.65
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3079
NSWW



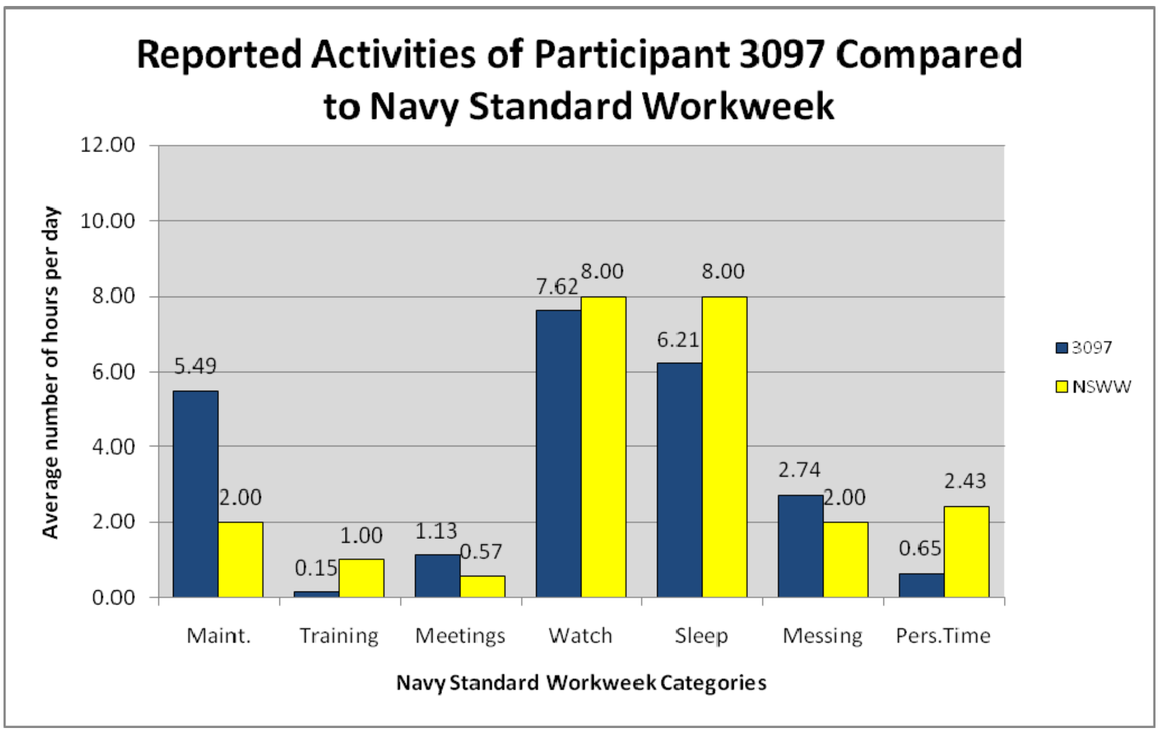
Reported Activities of Participant 3081 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2.68
2.00
0.79
1.00
6.43
0.57
2.68
8.00
5.50
8.00
2.54
2.00
3.39
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3081
NSWW



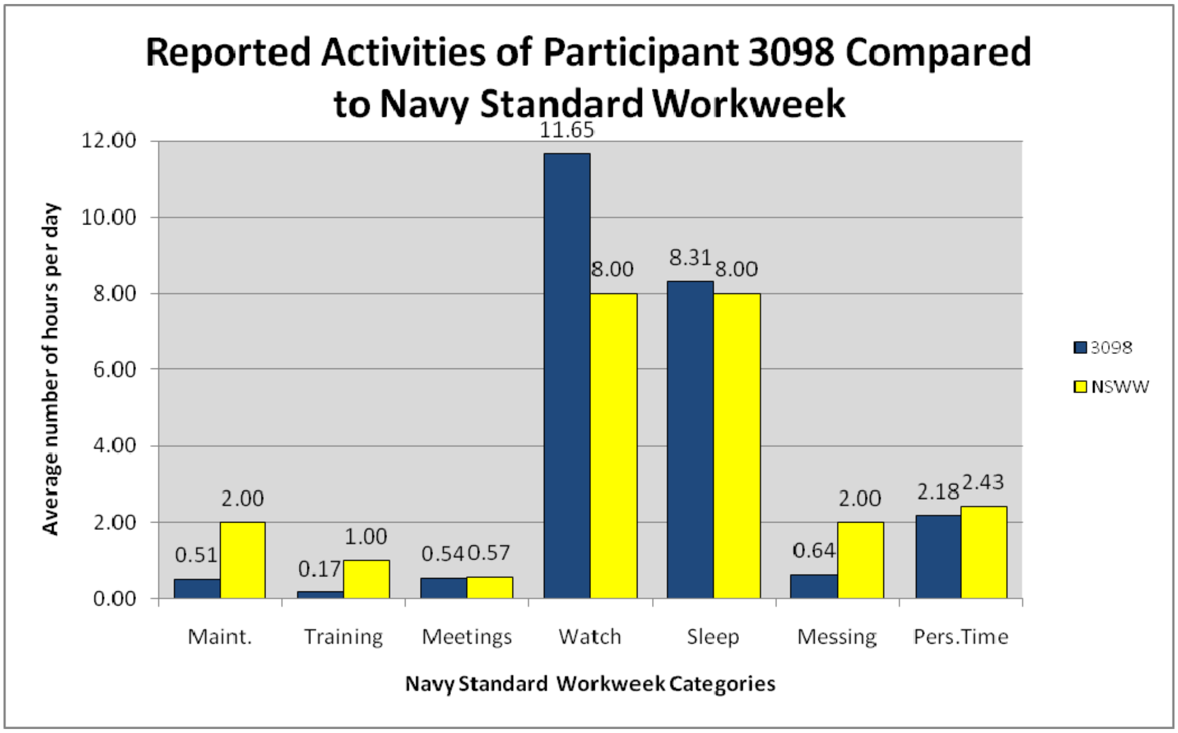
Reported Activities of Participant 3082 Compared to Navy Standard Workweek
Average number of hours per day
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.01
2.00
0.00
1.00
0.00
0.57
18.50
8.00
4.37
8.00
0.96
2.00
0.16
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3082
NSWW



Reported Activities of Participant 3086 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4.07
2.00
0.37
1.00
0.94
0.57
8.20
8.00
7.55
8.00
0.98
2.00
1.89
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3086
NSWW



Reported Activities of Participant 3097 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
5.49
2.00
0.15
1.00
1.13
0.57
7.62
8.00
6.21
8.00
2.74
2.00
0.65
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3097
NSWW


Reported Activities of Participant 3098 Compared to Navy Standard Workweek
Average number of hours per day
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.51
2.00
0.17
1.00
0.54
0.57
11.65
8.00
8.31
8.00
0.64
2.00
2.18
2.43
Maint.
Training
Meetings
Watch
Sleep
Messing
Pers.Time
Navy Standard Workweek Categories
3098
NSWW

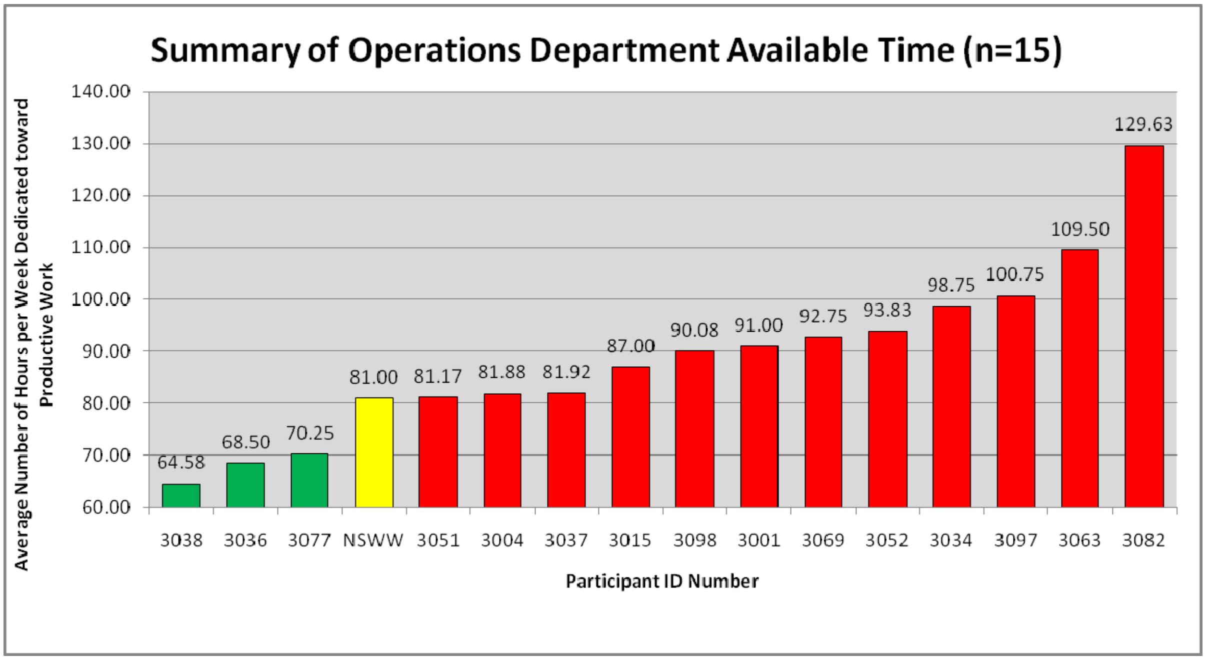
APPENDIX C. SUMMARY TABLE OF REPORTED ACTIVITIES OF INDIVIDUAL SAILORS

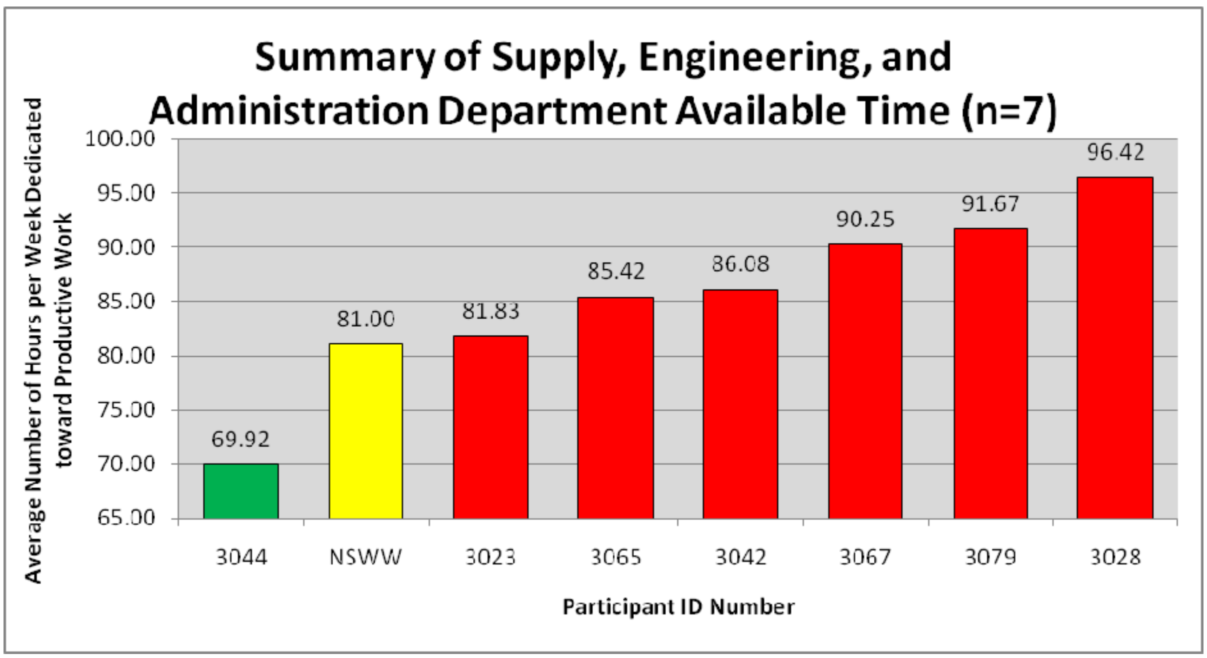
LAKE ERIE AVERAGE NUMBER OF HOURS SPENT PER WEEK							
Participant	**Maintenance**	**Training**	**Meetings**	**Watch**	**Sleep**	**Messing**	**Personal Time**
NSWW	**14**	**7**	**4**	**56**	**56**	**14**	**17**
3001	70.92	0.00	0.00	20.08	48.17	11.25	17.58
3004	16.75	2.13	4.38	58.63	50.50	12.13	23.50
3013	13.75	29.75	12.00	47.00	45.00	13.00	7.50
3015	15.17	10.42	5.75	55.67	50.17	9.58	21.25
3016	19.75	1.33	9.00	51.17	45.75	11.58	29.42
3018	31.08	20.83	3.58	40.50	47.75	3.25	21.00
3023	52.92	6.50	12.25	10.17	48.25	9.42	28.50
3028	24.58	5.67	4.25	61.92	44.08	15.83	11.67
3031	17.50	6.25	12.50	83.83	30.58	11.42	5.92
3032	24.83	0.92	0.42	73.08	54.42	6.50	7.83
3034	1.58	0.50	1.08	95.58	55.00	7.75	6.50
3036	11.38	0.25	2.75	54.13	67.38	10.75	21.38
3037	15.42	0.42	5.83	60.25	48.75	9.00	28.33
3038	5.08	0.00	2.25	57.25	51.75	7.00	44.67
3042	2.00	0.00	0.00	84.08	44.83	9.42	27.67
3044	51.42	13.33	3.42	1.75	51.50	17.92	28.67
3045	33.00	2.92	2.33	50.25	45.50	7.33	26.67
3079	30.25	1.42	2.50	57.50	44.50	20.25	11.58
3081	18.75	5.50	45.00	18.75	38.50	17.75	23.75
3086	28.50	2.58	6.58	57.42	52.83	6.83	13.25
3097	38.42	1.08	7.92	53.33	43.50	19.17	4.58
3098	3.58	1.17	3.75	81.58	58.17	4.50	15.25
AVERAGE	23.94	5.13	6.71	53.36	48.49	10.98	19.38
STD. DEVIATION	17.60	7.55	9.36	24.00	7.23	4.71	10.18

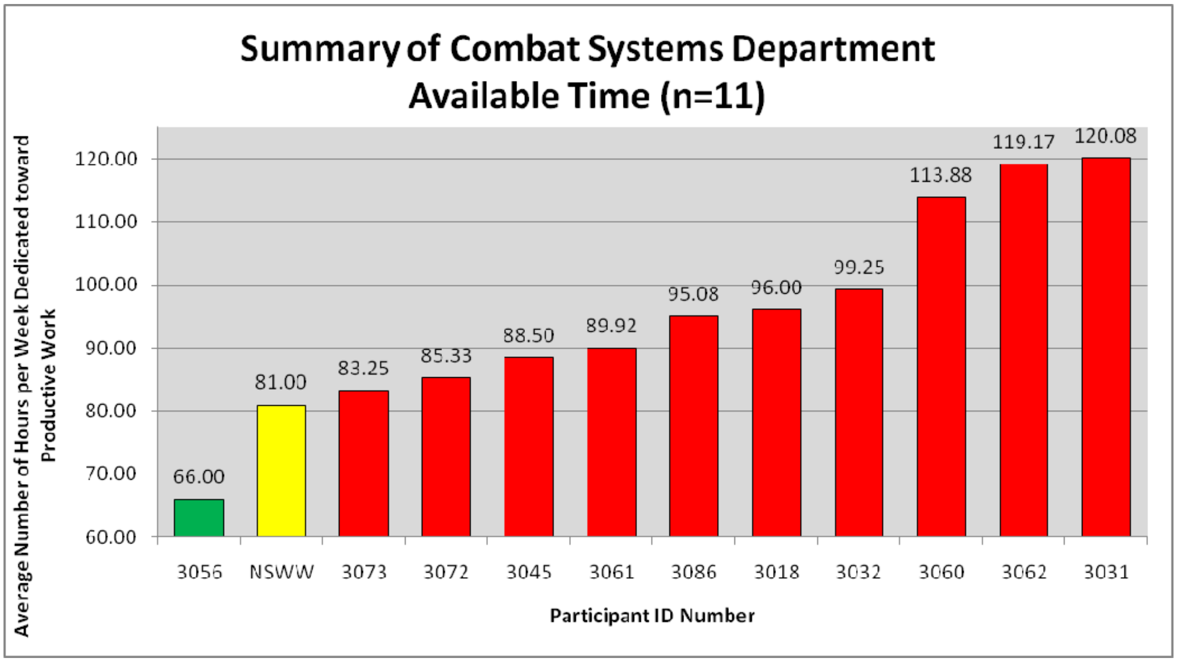
PORT ROYAL AVERAGE NUMBER OF HOURS SPENT PER WEEK							
Participant	**Maintenance**	**Training**	**Meetings**	**Watch**	**Sleep**	**Messing**	**Personal Time**
NSWW	**14**	**7**	**4**	**56**	**56**	**14**	**17**
3051	8.00	40.17	2.33	30.67	52.50	6.42	27.92
3052	5.75	0.75	0.00	87.33	41.00	5.67	27.50
3054	4.63	1.75	27.13	58.13	54.13	12.63	9.63
3055	26.58	1.00	13.42	51.17	59.33	8.17	8.33
3056	27.13	3.63	2.13	33.13	48.75	7.00	46.25
3058	27.17	3.33	8.08	57.75	50.83	6.33	14.50
3060	55.88	0.00	0.25	57.75	42.25	8.38	3.50
3061	6.33	2.42	0.00	81.17	60.00	7.00	11.08
3062	33.75	12.83	23.50	49.08	28.58	6.83	13.42
3063	78.75	1.25	2.50	27.00	47.50	8.25	2.75
3065	10.25	0.33	4.17	70.67	49.58	9.92	23.08
3067	4.13	0.00	0.13	86.00	58.25	3.25	16.25
3069	0.00	0.00	0.00	92.75	65.25	0.00	10.00
3072	35.83	0.83	7.17	41.50	42.33	7.58	32.75
3073	26.50	4.88	3.25	48.63	58.63	6.88	19.25
3077	15.00	1.63	0.00	53.63	62.00	0.00	35.75
3082	0.13	0.00	0.00	129.50	30.38	6.63	1.38
AVERAGE	21.52	4.40	5.53	62.11	50.08	6.52	17.84
STD. DEVIATION	21.31	9.72	8.32	26.47	10.55	3.13	12.69

APPENDIX D. SUMMARY DATA TABLE OF INDIVIDUAL SAILOR AVAILABLE AND NON-AVAILABLE TIME (EXC. OFFICERS)

PARTICIPANT	AVAILABLE TIME	NON-AVAILABLE TIME
NSWW	81.00	87.00
3001	91.00	77.00
3004	81.88	86.13
3015	87.00	81.00
3018	96.00	72.00
3023	81.83	86.17
3028	96.42	71.58
3031	120.08	47.92
3032	99.25	68.75
3034	98.75	69.25
3036	68.50	99.50
3037	81.92	86.08
3038	64.58	103.42
3042	86.08	81.92
3044	69.92	98.08
3045	88.50	79.50
3051	81.17	86.83
3052	93.83	74.17
3056	66.00	102.00
3060	113.88	54.13
3061	89.92	78.08
3062	119.17	48.83
3063	109.50	58.50
3065	85.42	82.58
3067	90.25	77.75
3069	92.75	75.25
3072	85.33	82.67
3073	83.25	84.75
3077	70.25	97.75
3079	91.67	76.33
3082	129.63	38.38
3086	95.08	72.92
3097	100.75	67.25
3098	90.08	77.92
AVERAGE	90.90	77.10
MEDIAN	90.08	77.92
STD. DEV.	15.33	15.33


Summary of Operations Department Available Time (n=15)
Average Number of Hours per Week Dedicated toward Productive Work
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
64.58
68.50
70.25
81.00
81.17
81.88
81.92
87.00
90.08
91.00
92.75
93.83
98.75
100.75
109.50
129.63
3038
3036
3077
NSWW
3051
3004
3037
3015
3098
3001
3069
3052
3034
3097
3063
3082
Participant ID Number


Summary of Supply, Engineering, and Administration Department Available Time (n=7)
Average Number of Hours per Week Dedicated toward Productive Work
100.00
95.00
90.00
85.00
80.00
75.00
70.00
65.00
69.92
81.00
81.83
85.42
86.08
90.25
91.67
96.42
3044
NSWW
3023
3065
3042
3067
3079
3028
Participant ID Number


Summary of Combat Systems Department
Available Time (n=11)
Average Number of Hours per Week Dedicated toward Productive Work
120.00
110.00
100.00
90.00
80.00
70.00
60.00
66.00
81.00
83.25
85.33
88.50
89.92
95.08
96.00
99.25
113.88
119.17
120.08
3056
NSWW
3073
3072
3045
3061
3086
3018
3032
3060
3062
3031
Participant ID Number

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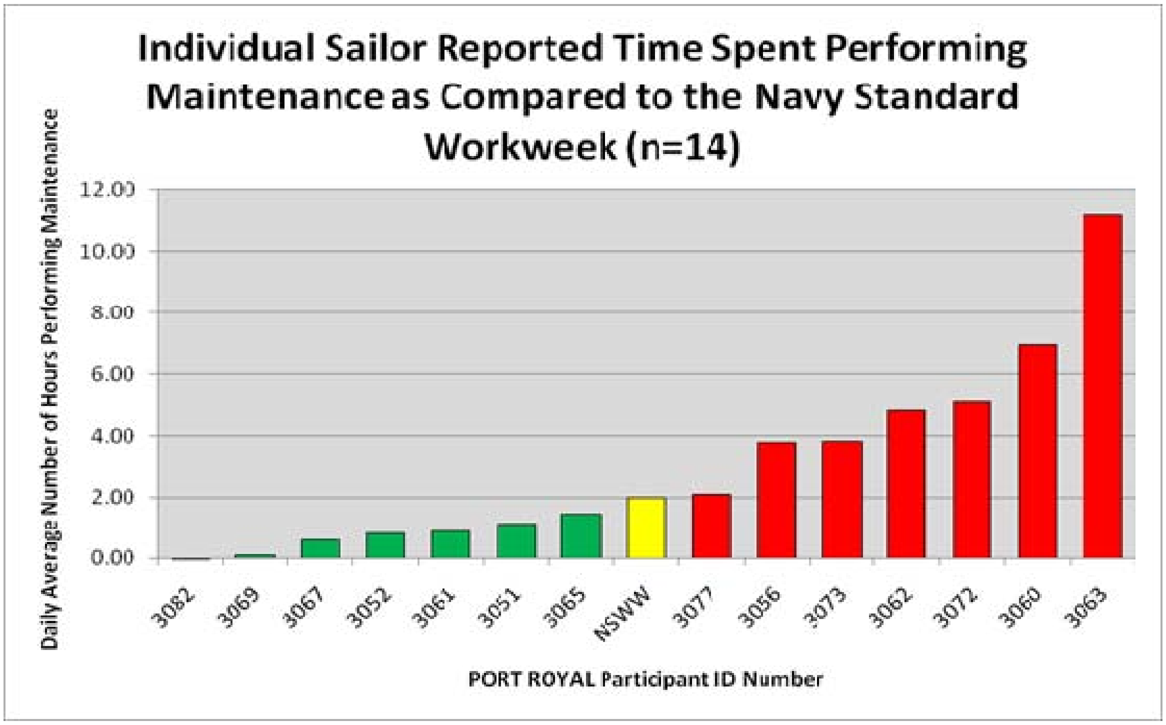
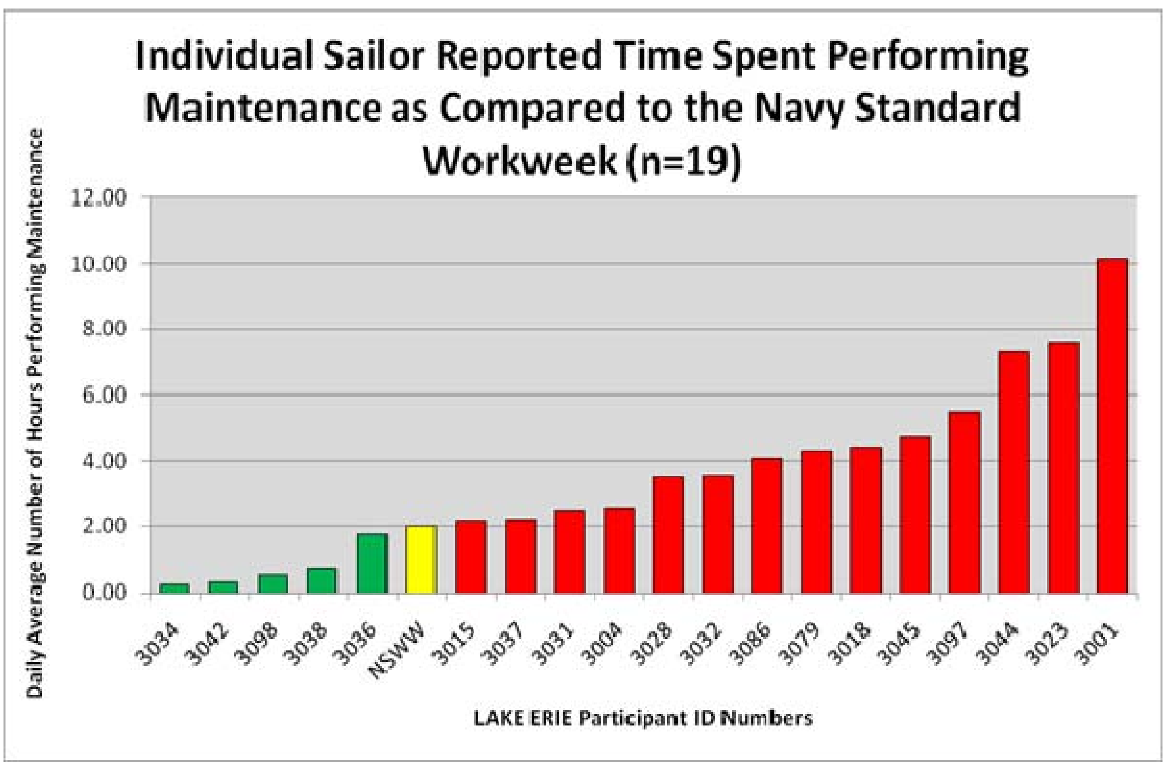
APPENDIX E. DISTRIBUTION OF CATEGORICAL EVENTS FOR AVAILABLE/NON-AVAILABLE TIME BY DEPARTMENT

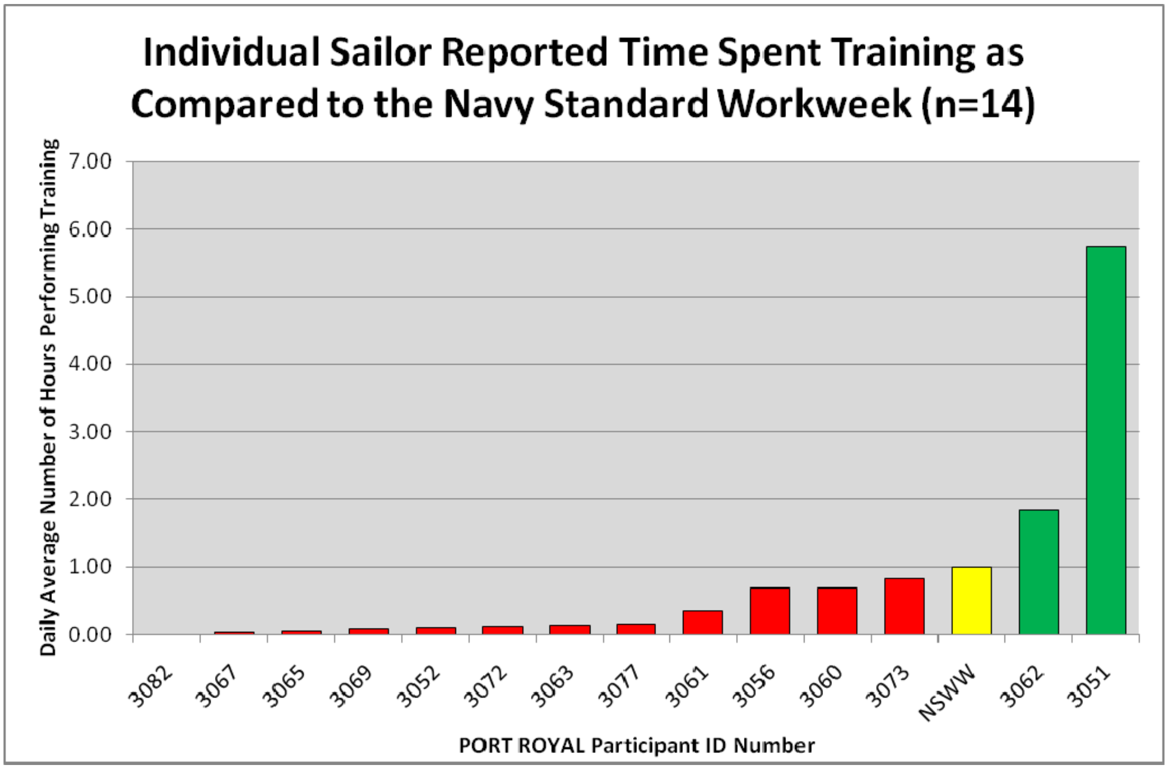
AVAILABLE TIME						
PERCENTAGES						
WATCH (Count)						
	<3 Hours	3-5 Hours	5-7 Hours	7-9 Hours	>9 Hours	Sum
Ops	3.5%	0.8%	4.8%	12.5%	21.7%	43.3%
Combat Sys	1.4%	0.8%	8.1%	11.9%	12.4%	34.5%
Engineering	0.0%	0.0%	1.2%	2.7%	2.4%	6.3%
Supply	5.7%	0.2%	0.8%	1.7%	4.4%	12.7%
Admin	0.0%	0.0%	0.0%	0.3%	2.9%	3.2%
Sum	10.6%	1.7%	14.9%	29.1%	43.7%	100.0%
PERCENTAGES						
MAINTENANCE (Count)						
	0-1 Hours	1-2 Hours	2-3 Hours	3-4 Hours	>4 Hours	Sum
Ops	22.8%	4.7%	4.1%	2.7%	9.0%	43.3%
Combat Sys	4.8%	2.9%	4.4%	4.2%	18.3%	34.5%
Engineering	0.6%	0.3%	1.1%	1.7%	2.7%	6.3%
Supply	4.7%	0.5%	0.8%	0.5%	6.3%	12.7%
Admin	2.1%	1.1%	0.0%	0.0%	0.0%	3.2%
Sum	35.0%	9.4%	10.3%	9.0%	36.3%	100.0%
PERCENTAGES						
TRAINING (Count)						
	0-1 Hours	1-2 Hours	2-3 Hours	3-4 Hours	>4 Hours	Sum
Ops	36.8%	1.4%	2.0%	1.1%	2.1%	43.3%
Combat Sys	25.3%	2.7%	2.7%	1.7%	2.1%	34.5%
Engineering	5.0%	0.5%	0.6%	0.2%	0.2%	6.3%
Supply	8.4%	2.4%	0.8%	0.8%	0.3%	12.7%
Admin	3.2%	0.0%	0.0%	0.0%	0.0%	3.2%
Sum	78.7%	6.9%	6.0%	3.6%	4.7%	100.0%
PERCENTAGES						
MEETINGS (Count)						
	0-1 Hours	1-2 Hours	2-3 Hours	3-4 Hours	>4 Hours	Sum
Ops	37.7%	3.6%	1.4%	0.3%	0.3%	43.3%
Combat Sys	24.3%	4.8%	2.6%	1.7%	1.2%	34.5%
Engineering	4.8%	1.1%	0.5%	0.0%	0.0%	6.3%
Supply	8.9%	2.3%	1.2%	0.2%	0.2%	12.7%
Admin	3.2%	0.0%	0.0%	0.0%	0.0%	3.2%
Sum	78.9%	11.8%	5.6%	2.1%	1.7%	100.0%

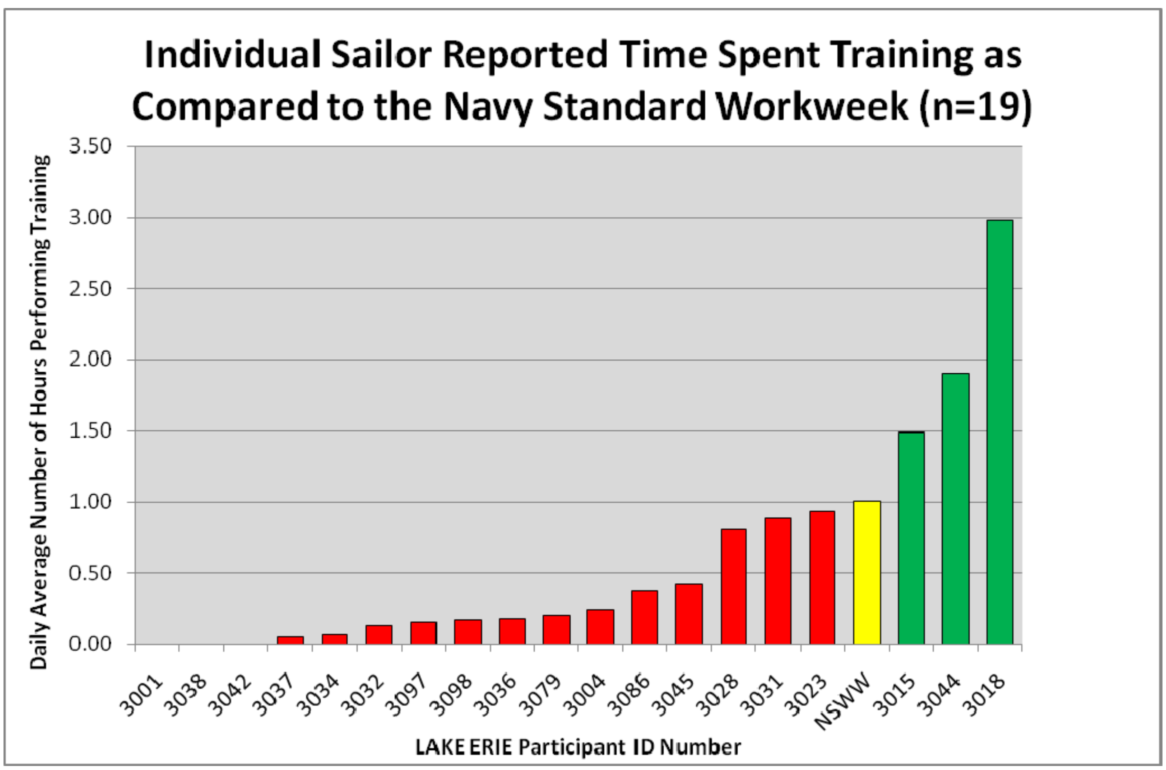
NON-AVAILABLE TIME						
PERCENTAGES						
SLEEP (Count)						
	<3 Hours	3-5 Hours	5-7 Hours	7-9 Hours	>9 Hours	Sum
Ops	1.8%	4.7%	11.6%	14.2%	11.0%	43.3%
Combat Sys	3.2%	6.3%	10.1%	6.5%	8.4%	34.5%
Engineering	0.0%	1.5%	3.0%	0.9%	0.9%	6.3%
Supply	0.2%	0.5%	5.0%	6.3%	0.8%	12.7%
Admin	0.2%	0.0%	0.5%	2.1%	0.5%	3.2%
Sum	5.3%	13.0%	30.2%	30.0%	21.6%	100.0%
PERCENTAGES						
PERSONAL TIME (Count)						
	0-1 Hours	1-2 Hours	2-3 Hours	3-4 Hours	>4 Hours	Sum
Ops	8.7%	12.4%	4.7%	5.4%	12.1%	43.3%
Combat Sys	10.3%	6.8%	4.8%	3.8%	8.9%	34.5%
Engineering	1.7%	2.6%	0.9%	0.8%	0.5%	6.3%
Supply	0.6%	1.4%	0.8%	3.5%	6.5%	12.7%
Admin	0.5%	0.6%	0.8%	0.2%	1.2%	3.2%
Sum	21.7%	23.7%	11.9%	13.6%	29.1%	100.0%
PERCENTAGES						
MESSING TIME (Count)						
	0-1 Hours	1-2 Hours	2-3 Hours	3-4 Hours	>4 Hours	Sum
Ops	15.5%	21.0%	5.4%	1.2%	0.2%	43.3%
Combat Sys	11.0%	22.5%	1.1%	0.0%	0.0%	34.5%
Engineering	0.2%	1.2%	2.6%	1.8%	0.6%	6.3%
Supply	1.1%	7.2%	3.8%	0.6%	0.0%	12.7%
Admin	3.0%	0.2%	0.0%	0.0%	0.0%	3.2%
Sum	30.8%	52.0%	12.8%	3.6%	0.8%	100.0%

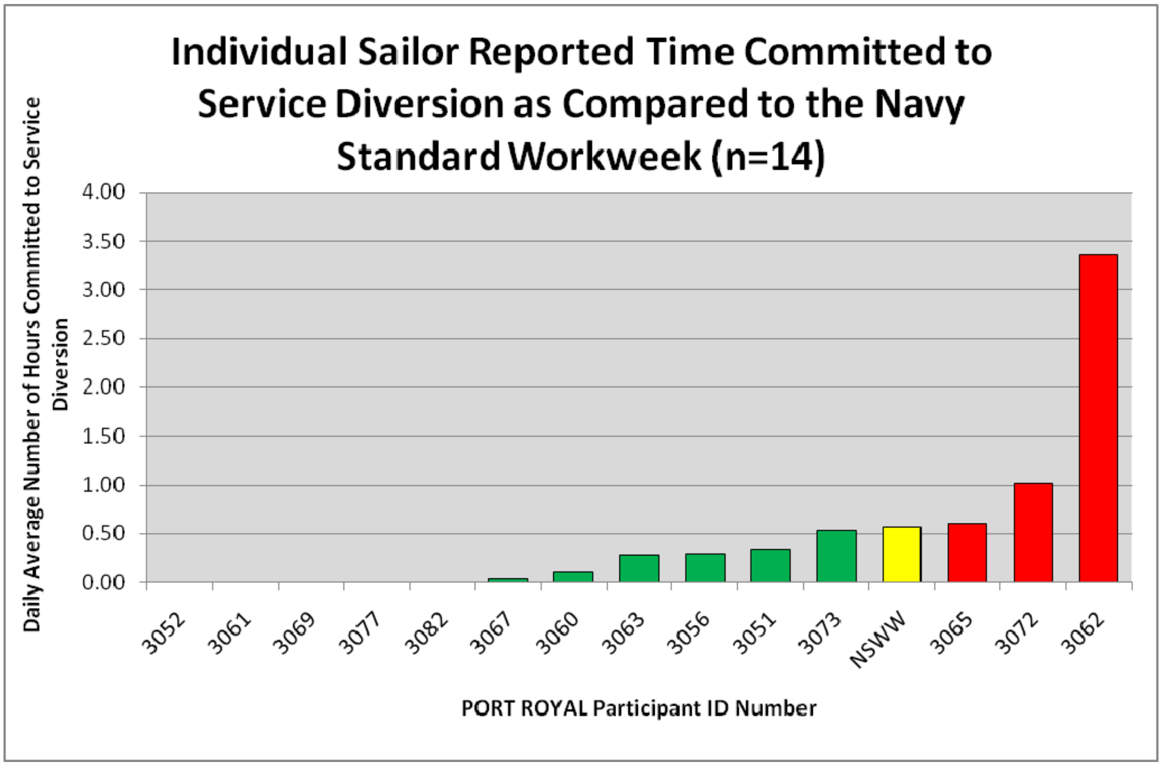
APPENDIX F. INDIVIDUAL SAILOR-REPORTED TIME COMPARED TO THE NAVY STANDARD WORKWEEK

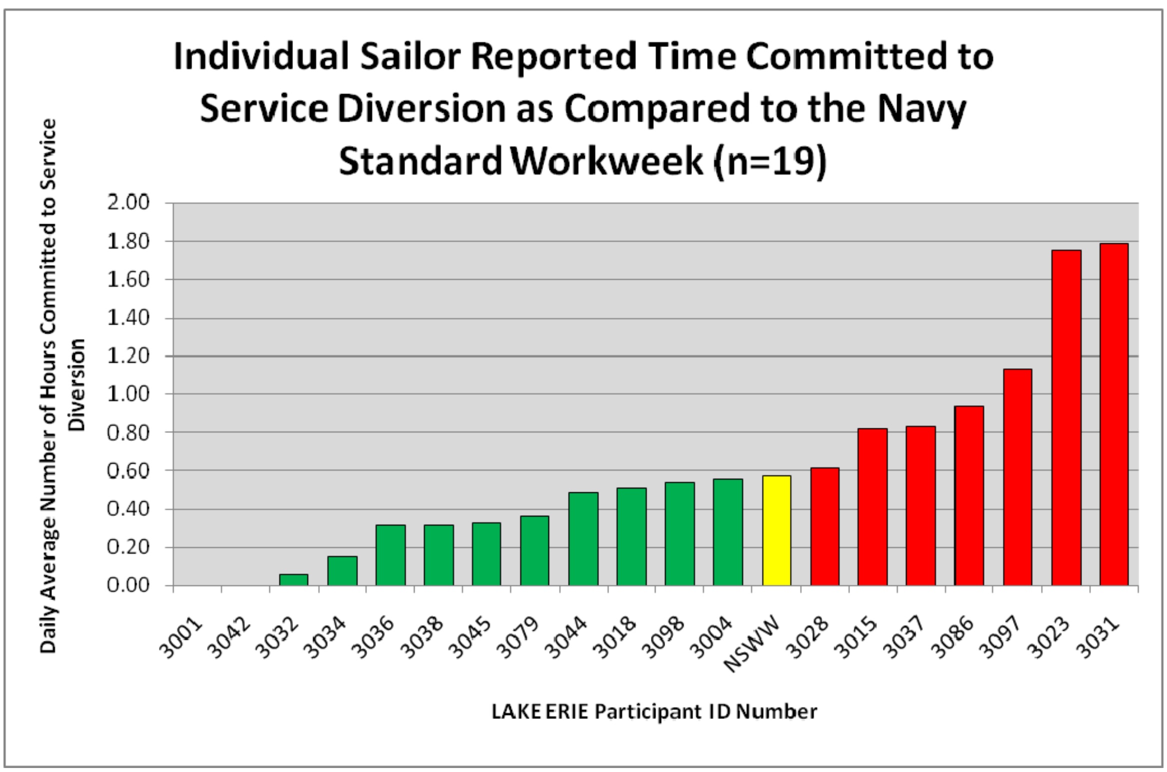


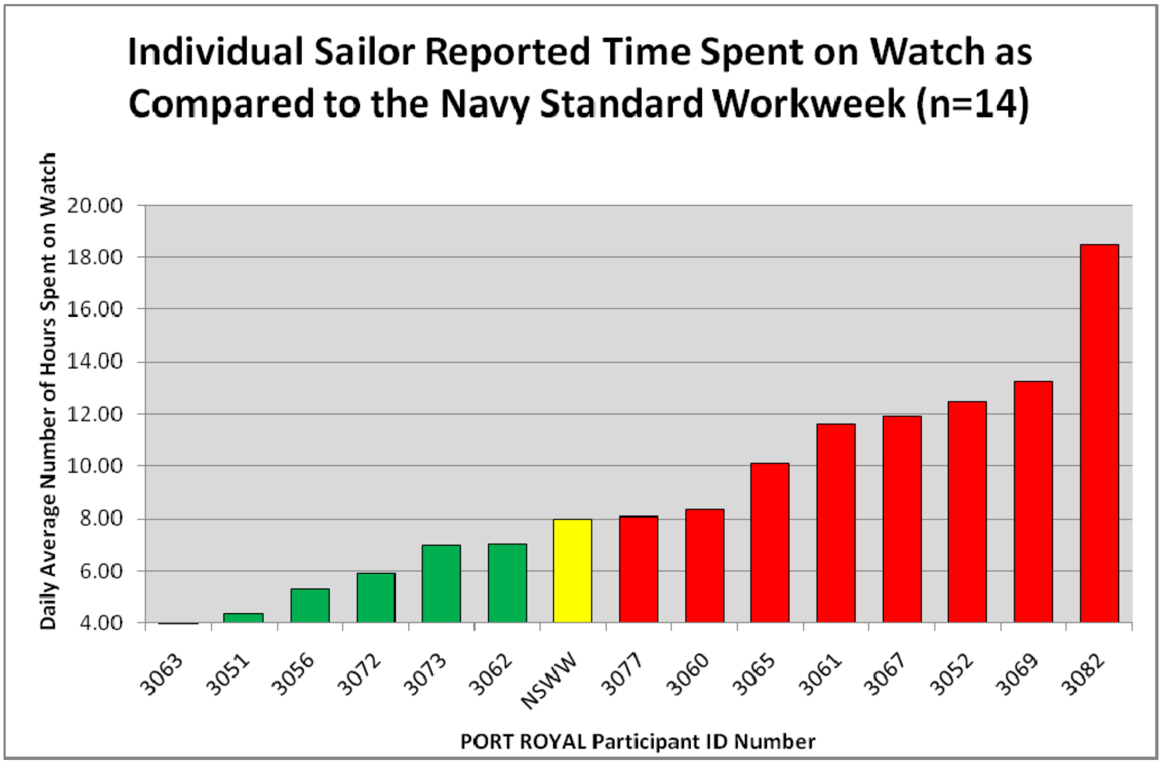



Individual Sailor Reported Time Spent Training as Compared to the Navy Standard Workweek (n=14)
Daily Average Number of Hours Performing Training
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
3082
3067
3065
3069
3052
3072
3063
3077
3061
3056
3060
3073
NSWW
3062
3051
PORT ROYAL Participant ID Number

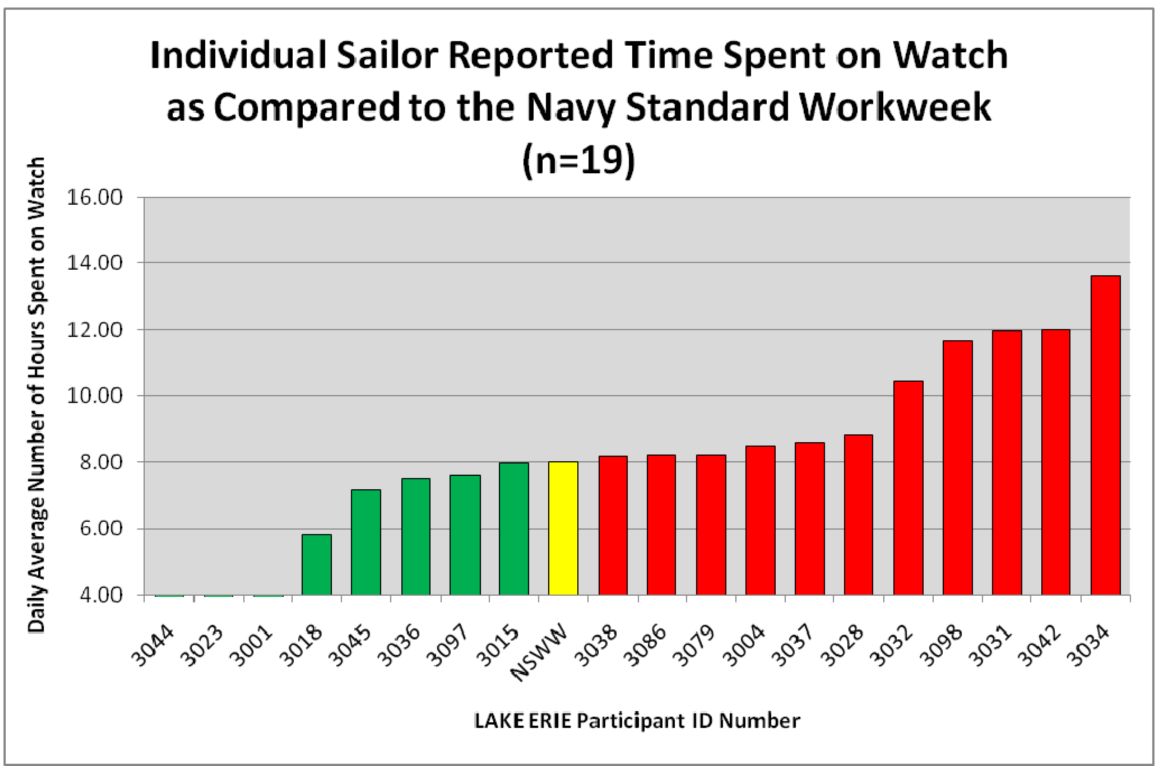

Individual Sailor Reported Time Spent Training as Compared to the Navy Standard Workweek (n=19)
Daily Average Number of Hours Performing Training
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
3001
3038
3042
3037
3034
3032
3097
3098
3036
3079
3004
3086
3045
3028
3031
3023
NSWW
3015
3044
3018
LAKE ERIE Participant ID Number


Individual Sailor Reported Time Committed to Service Diversion as Compared to the Navy Standard Workweek (n=14)
Daily Average Number of Hours Committed to Service Diversion
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
3052
3061
3069
3077
3082
3067
3060
3063
3056
3051
3073
NSWW
3065
3072
3062
PORT ROYAL Participant ID Number

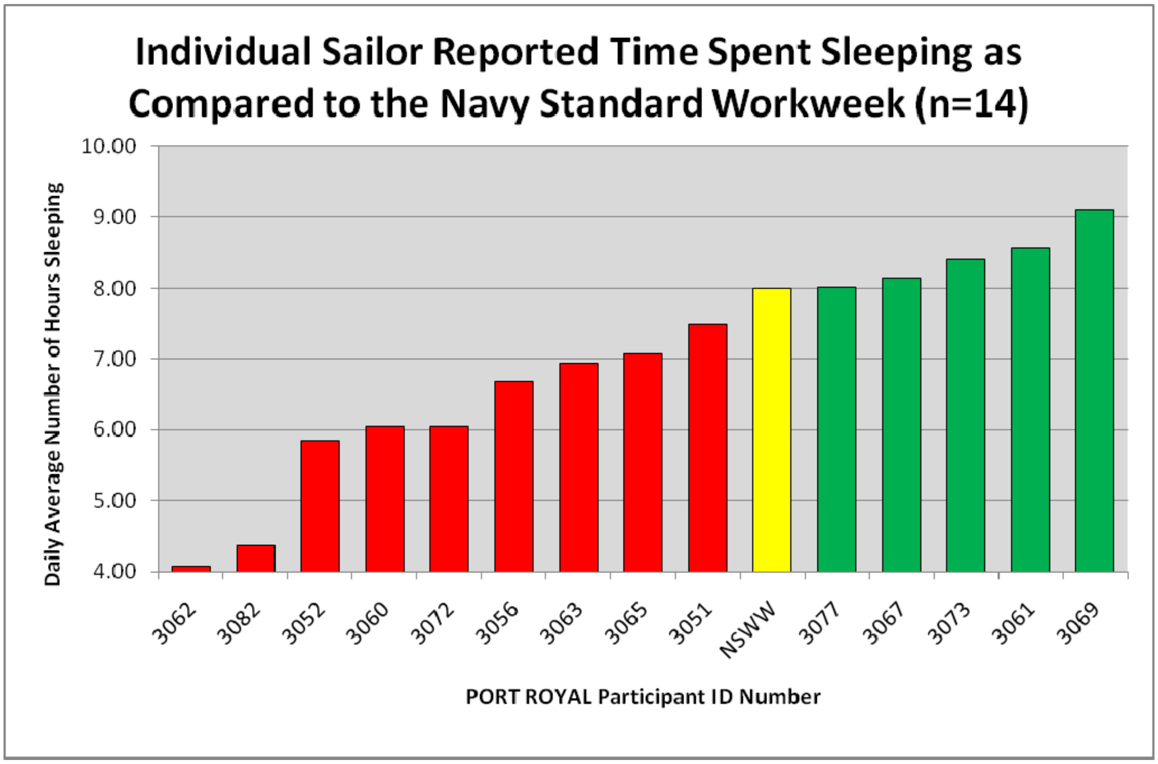

Individual Sailor Reported Time Committed to Service Diversion as Compared to the Navy Standard Workweek (n=19)
Daily Average Number of Hours Committed to Service Diversion
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
3001
3042
3032
3034
3036
3038
3045
3079
3044
3018
3098
3004
NSWW
3028
3015
3037
3086
3097
3023
3031
LAKE ERIE Participant ID Number

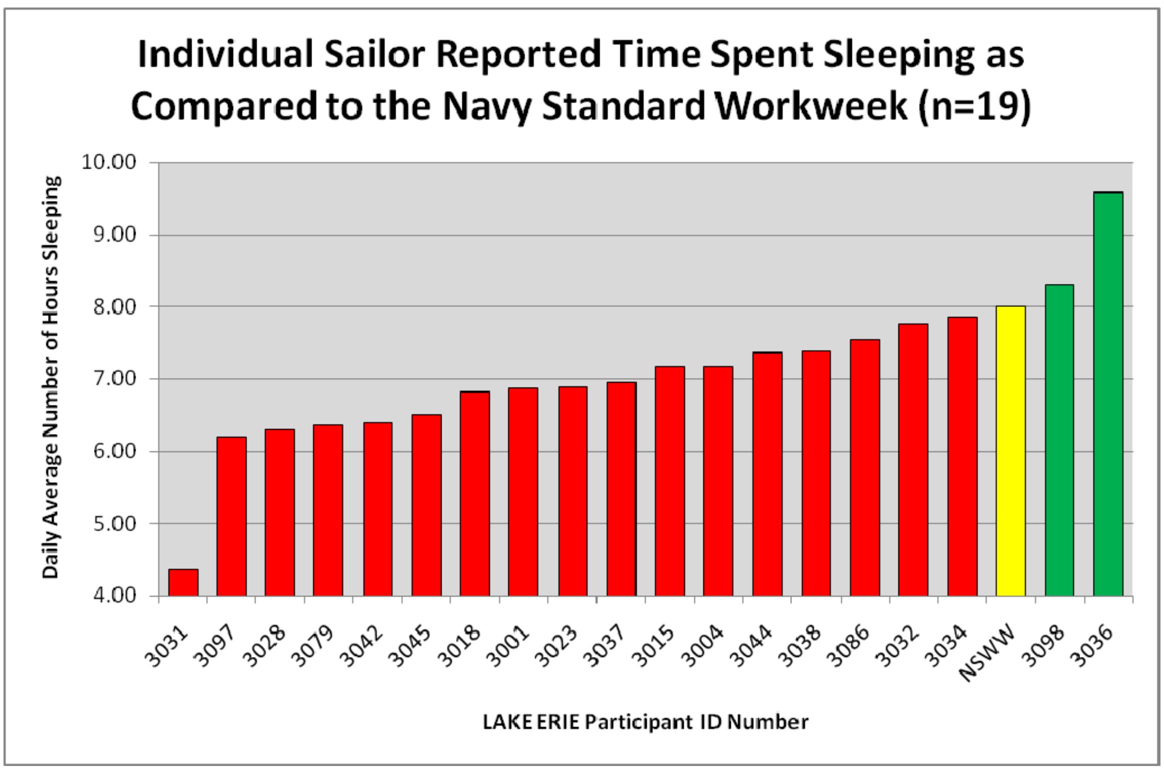


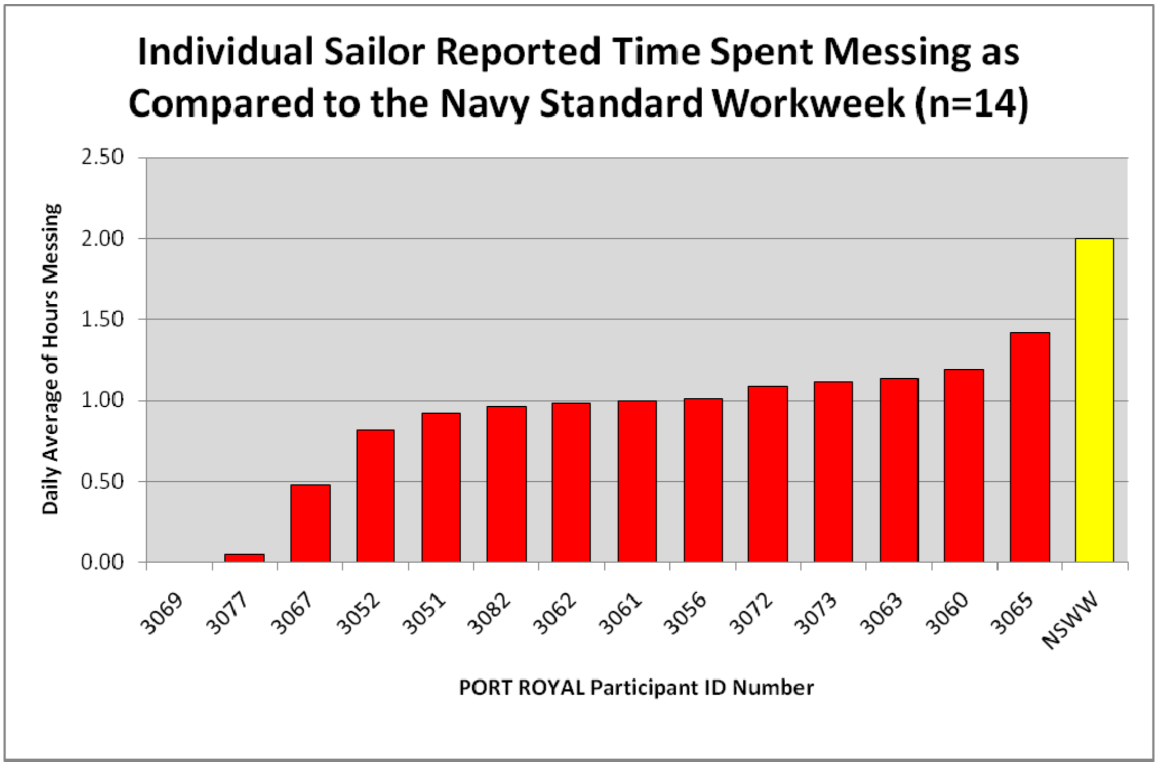
Individual Sailor Reported Time Spent on Watch as Compared to the Navy Standard Workweek (n=14)
Daily Average Number of Hours Spent on Watch
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
3063
3051
3056
3072
3073
3062
NSWW
3077
3060
3065
3061
3067
3052
3069
3082
PORT ROYAL Participant ID Number

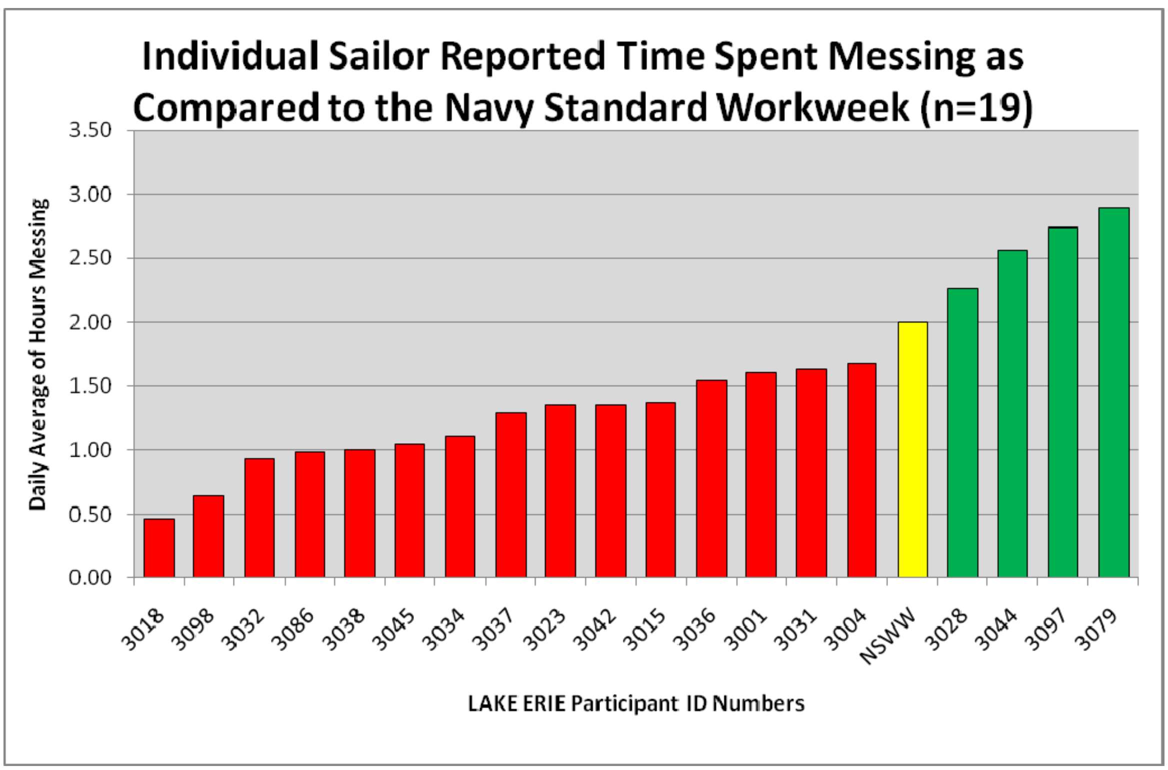


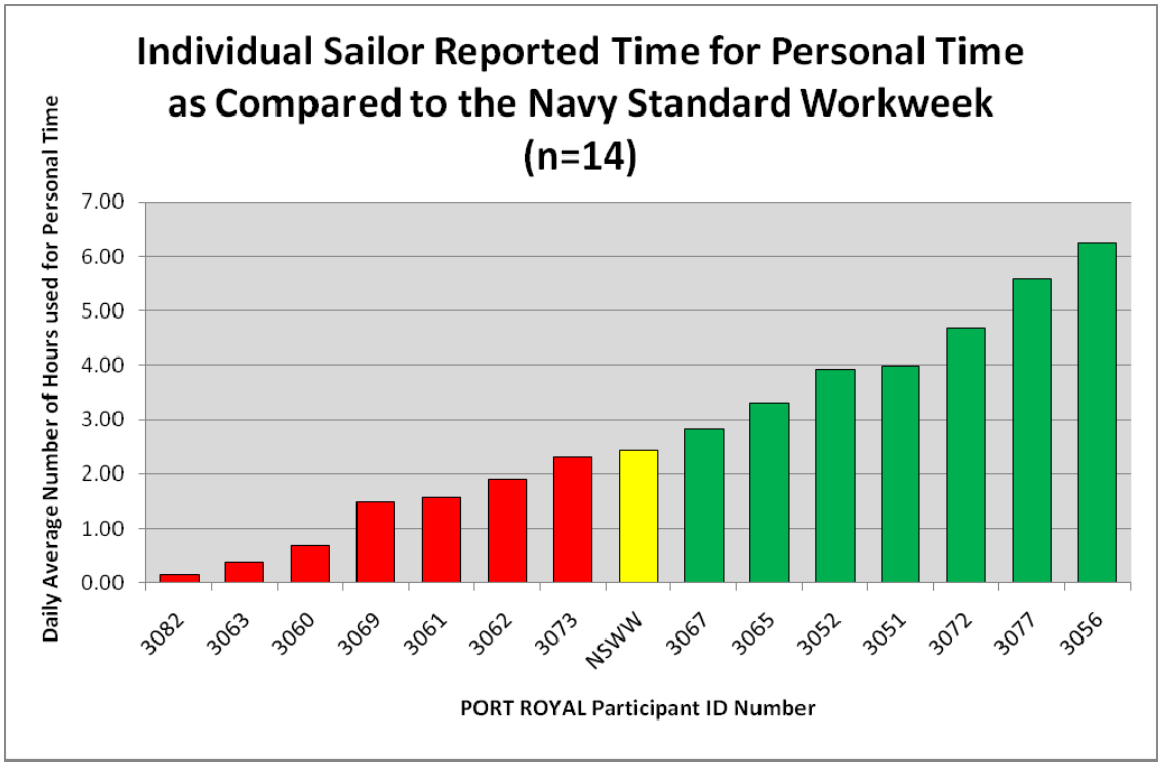
Individual Sailor Reported Time Spent on Watch as Compared to the Navy Standard Workweek (n=19)
Daily Average Number of Hours Spent on Watch
16.00
14.00
12.00
10.00
8.00
6.00
4.00
3044
3023
3001
3018
3045
3036
3097
3015
NSWW
3038
3086
3079
3004
3037
3028
3032
3098
3031
3042
3034
LAKE ERIE Participant ID Number

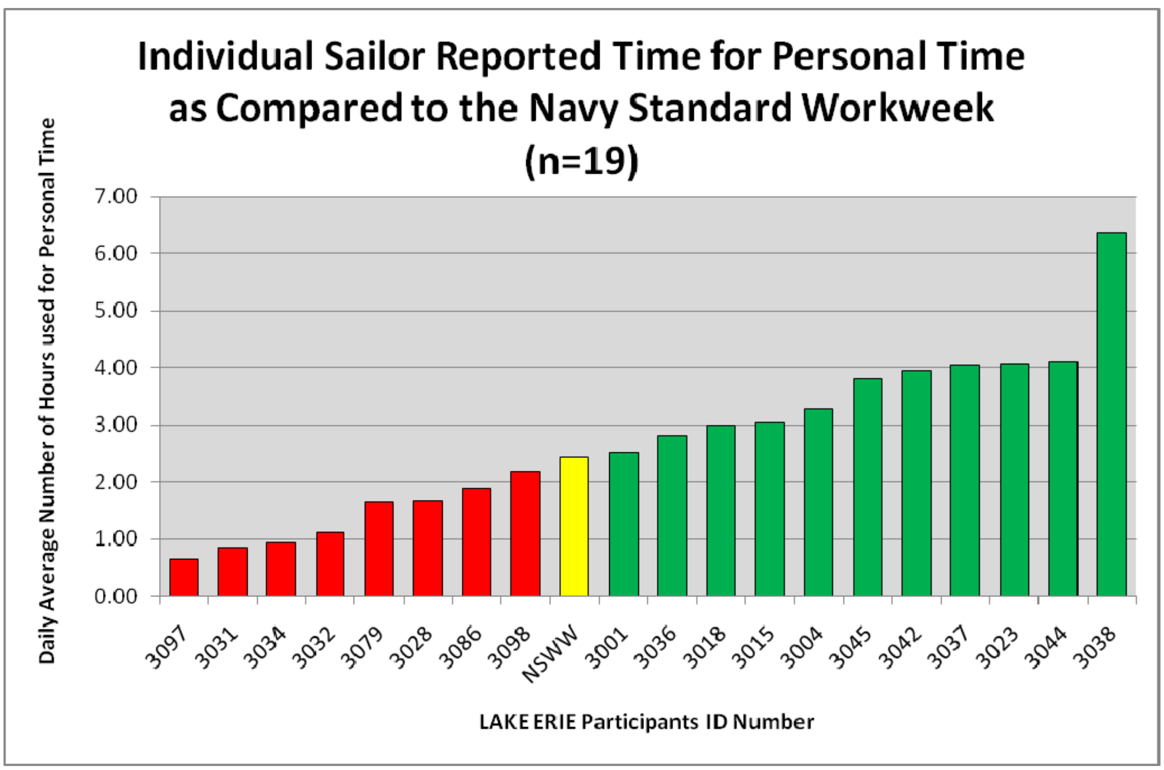

Individual Sailor Reported Time Spent Sleeping as Compared to the Navy Standard Workweek (n=14)
Daily Average Number of Hours Sleeping
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3062
3082
3052
3060
3072
3056
3063
3065
3051
NSWW
3077
3067
3073
3061
3069
PORT ROYAL Participant ID Number


Individual Sailor Reported Time Spent Sleeping as Compared to the Navy Standard Workweek (n=19)
Daily Average Number of Hours Sleeping
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3031
3097
3028
3079
3042
3045
3018
3001
3023
3037
3015
3004
3044
3038
3086
3032
3034
NSWW
3098
3036
LAKE ERIE Participant ID Number


Individual Sailor Reported Time Spent Messing as Compared to the Navy Standard Workweek (n=14)
Daily Average of Hours Messing
2.50
2.00
1.50
1.00
0.50
0.00
3069
3077
3067
3052
3051
3082
3062
3061
3056
3072
3073
3063
3060
3065
NSWW
PORT ROYAL Participant ID Number


Individual Sailor Reported Time Spent Messing as Compared to the Navy Standard Workweek (n=19)
Daily Average of Hours Messing
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
3018
3098
3032
3086
3038
3045
3034
3037
3023
3042
3015
3036
3001
3031
3004
NSWW
3028
3044
3097
3079
LAKE ERIE Participant ID Numbers


Individual Sailor Reported Time for Personal Time as Compared to the Navy Standard Workweek (n=14)
Daily Average Number of Hours used for Personal Time
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
3082
3063
3060
3069
3061
3062
3073
NSWW
3067
3065
3052
3051
3072
3077
3056
PORT ROYAL Participant ID Number


Individual Sailor Reported Time for Personal Time as Compared to the Navy Standard Workweek (n=19)
Daily Average Number of Hours used for Personal Time
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
3097
3031
3034
3032
3079
3028
3086
3098
NSWW
3001
3036
3018
3015
3004
3045
3042
3037
3023
3044
3038
LAKE ERIE Participants ID Number

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