

1 **Tenth International Conference on Managing Fatigue:**
2 **Abstract for Review**

4 **Comparing the work and rest hours of United States Navy Sailors with existing
5 maritime regulations**

7 Nita Lewis Shattuck, Operations Research Department, Naval Postgraduate School,
8 nlshattu@nps.edu

9 Panagiotis Matsangas, Operations Research Department, Naval Postgraduate School,
10 pmatsang@nps.edu (corresponding author)

12 **Problem**

13 Crewmembers in the United States Navy (USN) work long hours with limited
14 opportunities to sleep. Consequently, they are often sleep-deprived (Miller, Matsangas, &
15 Kenney, 2012). Their work schedules are an important contributor to their fatigue levels
16 (Shattuck & Matsangas, 2015; Shattuck, Matsangas, & Brown, 2015). Based on this
17 information, this study has two goals. First, we compare the work and rest patterns of
18 USN crewmembers with existing maritime regulations. Second, we investigate the
19 association between the watchstanding schedule and the level of compliance with
20 existing maritime fatigue regulations.

22 **Method**

23 This retrospective analysis uses data collected from 184 crewmembers of the Reactor
24 Department of the USS NIMITZ (CVN-68) (Shattuck & Matsangas, 2015; Shattuck et
25 al., 2015). In June 2014, participants (n=69) stood watch for 17 days using the 5hr-
26 on/10hr-off schedule. In November 2014, participants (n=115) stood watch for 11 days
27 using the 3hr-on/9hr-off schedule. Sleep was assessed with wrist-worn actigraphy and
28 daily activity logs. Activities were reported as standing watch, other duties (e.g.,
29 maintenance, etc.), training, service diversion (e.g., administrative requirements,
30 inspections, etc.), personal time, sleep, and meals.

32 Information from the activity logs was aggregated into two categories, Work and Rest, by
33 day (midnight to midnight). Work time included watch periods, ship duties, maintenance,
34 training, and service diversion. Rest included personal time, sleep, and meals.

35 Compliance rates were calculated using provisions from two regulations for seafarers, the
36 Maritime Labour Convention (MLC) (i.e., work \leq 14 hours/24-hour period, work \leq 72
37 hours/7-day period, rest \geq 77 hours/7-day) (ILO, 2006); and the United States Code
38 (USC) i.e., work \leq 36 hours/3-day period ("United States Code," 2016). In the absence of
39 specific US Navy regulations, we used the Navy Availability Factor (NAF) criterion (i.e.,
40 work \leq 81 hours/7-day period (*OPNAVINST 1000.16L*, 2015), and the Navy Standard
41 Work Week (NSWW) criterion for sleep \geq 56 hours/7-day period (*OPNAVINST*
42 *1000.16K*, 2007).

44 The Wilcoxon Rank Sum test was used for statistical comparisons. Post-hoc statistical
45 significance was assessed with the Benjamini–Hochberg False Discovery Rate (BH-
46 FDR) controlling procedure with q=0.20 (Benjamini & Hochberg, 1995).

47

48 **Results**

49 Participants were predominantly young (25.0 ± 3.72 years of age), male (80%), and
 50 enlisted (95%). Crewmembers worked more than 14 hours/day for 21% of their
 51 workdays. On a weekly basis, crewmembers worked more than 72 hours for 75% of their
 52 7-day periods, worked more than 81 hours for 53% of their 7-day periods, and rested less
 53 than 77 hours for 23% of their 7-day periods. Notably, the total (reported) sleep time was
 54 less than 56 hours (or approximately 8-hours/day) for 64% of the 7-day periods. This lack
 55 of sleep was also shown objectively by actigraphy data. Crewmembers working on the
 56 5/10 schedule slept on average 6.88 ± 0.93 hours/day, compared to 6.68 ± 0.95 hours of
 57 sleep for their 3/9 peers.

58 As shown in Table 1, the compliance rates differed by watchstanding schedule.
 59 Specifically, crewmembers working on the 3/9 were in greater compliance with existing
 60 maritime work/rest regulations when compared to their peers on the 5/10 schedule.

61

62 Table 1. Non-compliance rates by watchstanding schedule

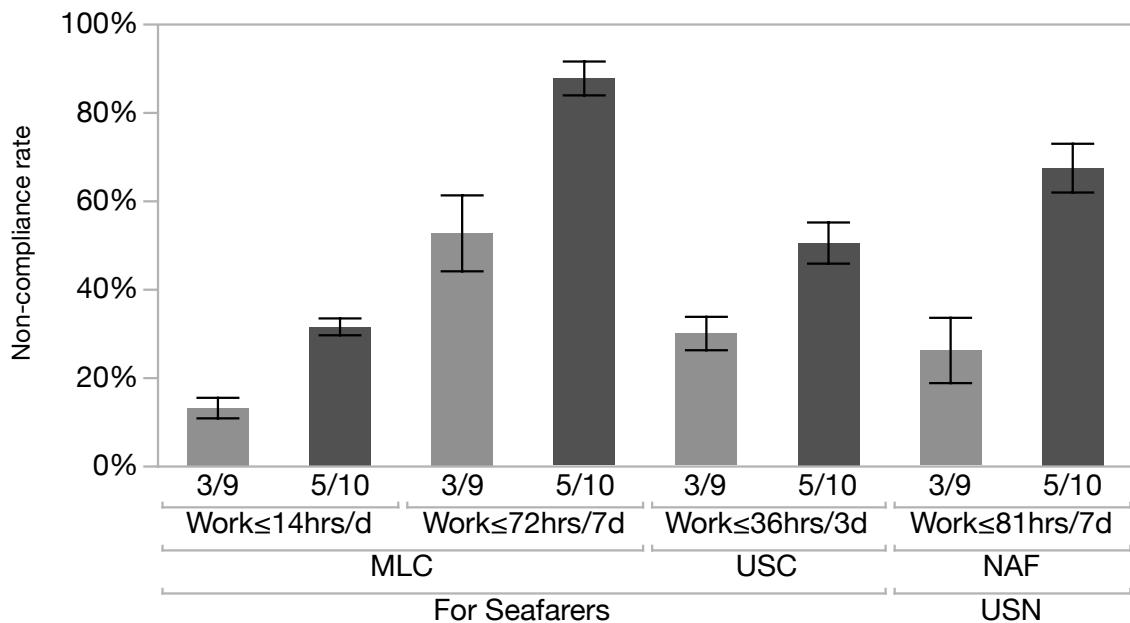
Regulation	Provision	Non-compliance rate		p-value	Effect size r
		3/9 M%±SD%	5/10 M%±SD%		
MLC	Work≤14hrs/d	13.0±22.2	31.3±15.6	<0.001 ^A	0.541
MLC	Work≤72hrs/7d	52.5±47.1	87.5±28.4	<0.001 ^A	0.399
USC	Work≤36hrs/3d	29.8±35.6	50.3±37.2	<0.001 ^A	0.282
NAF	Work≤81hrs/7d	26.0±40.5	67.3±40.9	<0.001 ^A	0.428
MLC	Rest≥77hrs/7d	6.67±25.3	32.6±39.6	<0.001 ^A	0.419
NSWW (obs.)	Sleep≥56hrs/7d	58.2±47.2	69.6±35.3	0.470	0.077

63 ^A Statistical significant based on the BH-FDR

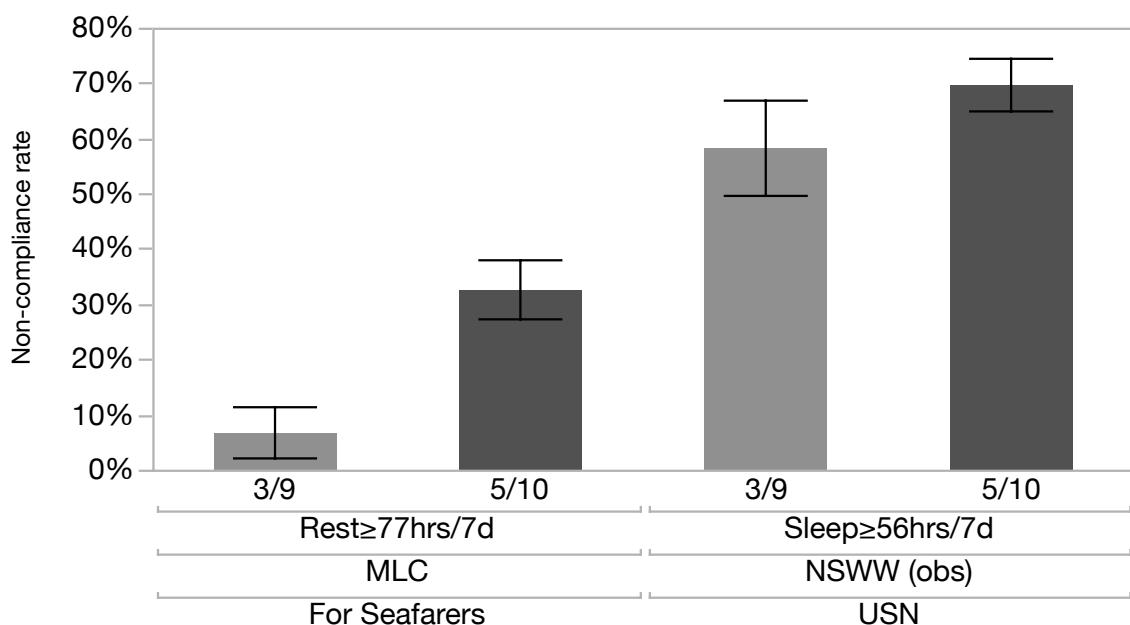
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65 The overall non-compliance rates by regulation are shown in Figures 1 and 2. Vertical
 66 lines denote the standard error.

67



68
69 Figure 1: Non-compliance rates by work hours criterion
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72 Figure 2: Non-compliance rates by rest/sleep hours criterion
73

74 Discussion

75 Our results show that crewmembers work long hours, both in terms of daily work, and
76 accumulated work hours per 7-day period. It is notable that crewmembers on the 5/10
77 schedule worked more than 72 hours for 88% of their 7-day periods. Consequently, it was

78 not a surprise that the non-compliance rates for the criterion of at least 56 hours of sleep
79 per 7-day period was high, reaching 70% for the crewmembers working on the 5/10.
80 Even though the 3/9 was associated with a clear improvement in all the work and rest
81 provisions (non-compliance rates were markedly decreased), some non-compliance
82 metrics were still high.

83 These results show that crewmembers working at sea have high workloads for extended
84 periods of time. Various inelastic tasks and operational commitments may contribute to
85 increased workload, and, hence, limited opportunities to rest and sleep. It is interesting,
86 however, that the increase in the non-compliance rates from the 3/9 to the 5/10 far
87 exceeds the difference in personnel between the two schedules. Theoretically, a station
88 manned for a 4-section 3/9 schedule needs 25% more personnel than a 3-section 5/10
89 schedule. On average, however, the non-compliance rates for the 5/10 increased by
90 140%. The non-compliance rates for the MLC Rest provision showed a 4-fold increase
91 for the 5/10 compared to the 3/9. These findings emphasize the non-linear characteristics
92 of the naval operational environment, and the importance of optimizing shiftwork and
93 work scheduling at sea.

94

95 **Summary**

96 As part of a multiyear project, multiple studies have been conducted at the Naval
97 Postgraduate School to systematically and empirically assess the work and rest patterns
98 of crewmembers working on U.S. Navy ships. This study compared the compliance of
99 crewmembers' work/rest hours with existing regulations. Overall, non-compliance rates
100 were high, up to 88% of the crew. Results highlight how crewmembers work long hours
101 with limited opportunities to rest. The watchstanding schedules of the crewmembers had
102 a significant impact on the compliance rates. In the absence of specific Navy regulations
103 to manage work and rest schedules, the US Navy should consider using standard
104 maritime regulations that include guidance for optimal management of work/rest/sleep
105 patterns.

106

107 **Disclaimer**

108 The views expressed in this document are those of the authors and do not reflect the
109 official policy or position of the Department of Defense or the U.S. Government.