Circadian Lighting for U.S. Navy Submarines

The submarine environment is unique. In few other places than a submarine are individuals exposed to constant, low light from fluorescent lamps for three to six months at a time.

Submariners have historically operated on 18-hour based rotating watch schedules, which is outside the periodicity range required for human circadian entrainment. As a result, personnel working on submarines often experience circadian misalignment, which can lead to poor sleep, reduced performance, and long-term health consequences, including diabetes, cardiovascular disease and certain forms of cancer.

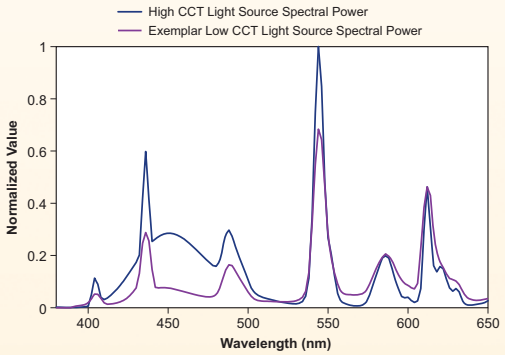
Based upon previous LRC field research conducted in the submarine environment comparing 18-hour shifts with 24-hour shifts, the U.S. Navy is transitioning to 24-hour based watch schedules. The present study was designed to provide enhanced lighting during work hours to further enhance circadian entrainment.

Experimental, high correlated color temperature (CCT = 13500 K) fluorescent light sources were installed in a U.S. Navy submarine to replace the standard issue fluorescent light sources (CCT = 4100 K). A variety of outcome measures were employed to determine if exposure to the high CCT light during on-duty times would promote circadian entrainment.

Combining a 24-hour shift with enhanced circadian light during work resulted in:

- Better sleep
- Better alignment of melatonin with sleep
- Feeling more awake during the work shift
- Better entrainment of activity-rest with light-dark patterns

The results of this military field study are consistent with the LRC's theoretical understanding that regular, 24-hour, light-dark exposure patterns combined with high circadian light exposures during waking hours can promote circadian entrainment and sleep. Therefore, this approach appears to be beneficial to submarine crew members during undersea operations.



Spectral power distributions of the experimental, high CCT (13500 K) light source used in the present study and an exemplar low CCT lamp (4100 K), similar to the standard issue light source used on USN submarines. The high CCT lamp has a color rendering index (CRI) of 83 and a gamut area index (GAI) of 103; the low CCT lamp has a CRI of 62 and a GAI of 58.

Acknowledgments

Funding for this protocol was provided through a combination of grants from the Commander of Submarine Forces (N0002413WX10137), Navy Bureau of Medicine and Surgery (Form 2189-1 Direct Funding), and Office of Naval Research (N0001411WX21542, N0001408WR20041, and N0001408WR30182).
GE Lighting provided the light sources used in the study.

Citation

Young CR, Jones GE, Figueiro MG, Soutière SE, Keller MW, Richardson AM, Lehmann BJ and Rea MS. At-Sea Trial of 24-h-Based Submarine Watchstanding Schedules with High and Low Correlated Color Temperature Light Sources. *J Biol Rhythms*. 2015; 30: 144-54.

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