



Commentary: Brightness of the Night Sky Affects Loggerhead (*Caretta caretta*) Sea Turtle Hatchling Misorientation but Not Nest Site Selection

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A Commentary on

Brightness of the Night Sky Affects Loggerhead (*Caretta caretta*) Sea Turtle Hatchling Misorientation but Not Nest Site Selection

by Stanley, T. R., White, J. M., Teel, S., and Nicholas, M. (2020). *Front. Mar. Sci.* 7:221. doi: 10.3389/fmars.2020.00221

INTRODUCTION

As research in the field of artificial light at night has increased and more sophisticated quantification of the influence of light is required, ecologists have been seeking a method to quickly and cost-effectively measure artificial light at night. Measuring light at night in a biologically meaningful way is complicated, and requires specialist knowledge (Swaddle et al., 2015; Hänel et al., 2018). It is therefore potentially tempting to adopt tools developed for other disciplines, such as the low-cost and easy-to-use radiance meter “Sky Quality Meter” (SQM), and the SQM-L model, which have both been widely used in night sky brightness studies. Unfortunately, in some cases these instruments are being used for purposes beyond which they were intended. Stanley et al. (2020) used SQMs to make observations of radiance from a series of points on the sky dome, with the intention of thereby measuring hemispherical light levels, to investigate their influence on sea turtle nesting location and hatchling behavior. We appreciate their intention to measure angularly resolved radiance, their analysis and conclusions, and do not disagree with their ultimate recommendations. However, we are concerned that the radiance data are unreliable because of an inadvisable use of an SQM. For this reason, we recommend that researchers do not use SQMs to measure light from very heterogeneous scenes (including the horizon) for biological and ecological studies, because those data could be difficult to reproduce and interpret, and therefore open to challenge.

SKY QUALITY METERS SHOULD NOT BE USED TO MEASURE HORIZON BRIGHTNESS

The problem with using SQMs to measure horizon and near horizon brightness arises because the SQM is designed to make observations of a roughly homogeneous field of light without bright glare sources. First, the horizon does not match this description, as it demarcates a dramatic transition in brightness between the land or sea and the sky. In artificially lit locations it can also include illuminated objects or bright point sources of light. Unless extraordinary care is taken to position and direct the SQM identically from one observation to the next, an observation from an SQM aimed toward the horizon will not be replicable, leading to a measurement error. Second, when aimed at the horizon, the field of view includes the area below the horizon, resulting in average radiance much less than the brightness of the sky in the region (Duriscoe et al., 2015). Third, manufacturer instructions for use of the SQM warn that direct glare on the faceplate sensor should be avoided to prevent light being reflected internally. Fourth, in the presence of bright sources near horizon the SQM will overestimate radiance of the sky even if the SQM does not point close to horizon (Duriscoe et al., 2015). This is because the sensitivity of the SQM at high angles is still not zero and can reach about 2% of its maximal sensitivity up to 70° from the pointing direction (Sánchez de Miguel et al., 2017).

Recommendations for using an SQM were provided by Hänel et al. (2018). They described the measurement error in the instrument, and recommended intercalibration and methods for data collection to reduce error (i.e., reject first few readings, allow the SQM to warm up, rotate the SQM around all 4 cardinal directions while aiming at the zenith etc.). Cinzano (2005, 2007) provided an early review on the use, precision and accuracy of SQM, and a growing body of literature has built on this work (for example see den Outer et al., 2011, 2015; Duriscoe et al., 2015; Sanchez et al., 2017). Stanley et al. (2020) used a tripod for pointing, but otherwise did not report following these recommended methods.

DISCUSSION

Stanley et al. (2020) are not alone in the inappropriate use of SQMs to measure light at the horizon. Other papers and

theses have been published with this approach (e.g., Bonner, 2015; Kelly et al., 2017; Price et al., 2018; Windle et al., 2018). We hope that future research on light pollution in coastal environments, and in ecology more broadly, avoids this misuse of the SQM for horizon measurements. Studies that use an SQM for skyglow monitoring should, as a minimum, avoid the region up to 30 degrees above the horizon, and report all details of the SQM configuration, specifications, and data collection methods used, including viewing angles and directions, presence of point sources toward the horizon, and values and variance of replicate measurements, to provide confidence in the precision and accuracy of the results (Zamorano et al., 2014). Biologists should familiarize themselves with the operation and limitations of the SQM, and the potential complicating factors influencing measurement, such as the airglow band between the horizon and 20 degrees above it, clouds, and atmospheric aerosols. We encourage biologists to explore other options that are now becoming more readily available to measure both point source lights and sky glow, at or near the horizon. The most widely recommended method is digital camera-based photography (using a fisheye lens to capture the whole sky). When correctly calibrated, this method provides both qualitative (imagery) and quantitative (skyglow radiance) data (Hänel et al., 2018; Barentine, 2019; Jechow et al., 2019). While slightly more expensive, this technique can be used to examine different sectors of the sky accurately, allowing better quantification of local conditions that may be important to species responses.

AUTHOR CONTRIBUTIONS

TL and KP wrote the first draft. All authors contributed to, reviewed, and edited the final text.

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The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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