RESOURCE OF INTEREST

LIGHT POLLUTION GUIDELINES TO PROTECT MARINE TURTLES

KAREN ARTHUR[1,#], SCOTT WHITING[2] & KELLIE PENDOLEY[3]

[1]Australian Commonwealth Department of Agriculture, Water and the Environment, Canberra ACT, Australia

[2]Western Australian Department of Biodiversity, Conservation and Attractions, Kensington WA, Australia

[3]Pendoley Environmental, Booragoon WA, Australia

[#]Karen.Arthur@awe.gov.au

Artificial light is increasing globally by around 2% per year (Kyba *et al*., 2017) and it is recognised as an emerging conservation issue for wildlife (Russart & Nelson, 2017). Hatchling marine turtles are vulnerable to light pollution as it disrupts natural light cues used for finding the ocean (Witherington & Martin, 2003) and dispersing through the nearshore environment (Thums *et al*., 2016; Wilson *et al*., 2018). Artificial light may also deter adult marine turtles from nesting on lit beaches (Salmon, 2003). Increases in artificial light have been observed to affect marine turtles globally (Lutcavage *et al*., 2017), and artificial light has been identified as a threat to marine turtles in the Indian Ocean region (Karnad *et al*., 2009; Kamrowski *et al*., 2012, Department of Biodiversity Conservation and Attractions, 2017; Chalastani *et al*., 2020).

To address this conservation challenge, the Australian Department of Agriculture, Water and the Environment in collaboration with the Western Australian Department of Biodiversity, Conservation and Attractions has developed *National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth of Australia, 2020)*. The *Light Pollution Guidelines* aim to raise awareness of the potential impacts of artificial light on marine turtles and provide a framework for assessing and managing these impacts near important nesting beaches. This framework provides foundational knowledge on the potential biological impacts of artificial light, as well as consistent, standardised and transparent processes and expectations for assessing, measuring, auditing and managing artificial light around wildlife.

BEST PRACTICE LIGHT DESIGN PRINCIPLES

The Light Pollution Guidelines advocate a best practice approach to managing artificial light for wildlife, including reducing sky glow. To reduce sky glow these best practice principles (Figure 1) should be implemented for all outdoor lighting:

1. Start with natural darkness. Identify the reason for artificial light and only add light for specific purposes.
2. Use adaptive, smart controls for lighting. Advances in technology mean that lighting can be controlled by timers, motion sensors, and automatic dimmers.
3. Avoid light spill. Only light the intended area or objects. Keep lights close to, and oriented towards the ground as upward light contributes to sky glow.
4. Use the lowest intensity lighting appropriate to the task. Lighting should be the lowest intensity needed to illuminate the area of interest.
5. Use non-reflective surfaces. Reflected light can contribute to sky glow.
6. Use lights with little or no blue wavelengths. Shorter wavelength (blue) light refracts more as it travels through the atmosphere, contributing more to sky glow than longer wavelength (yellow, orange and red) light. Also, turtle hatchlings are more sensitive to blue-green wavelengths than orange-red.

ENVIRONMENTAL IMPACT ASSESSMENT FOR ARTIFICIAL LIGHT

Around important marine turtle nesting beaches, the Light Pollution Guidelines recommend an Environmental Impact Assessment (EIA) approach. This should include consideration of the biological management objectives regarding artificial light, the proposed lighting design and mitigation and a risk assessment including the likelihood and consequence to nesting marine turtles or hatchlings. The effectiveness of mitigation should always be reviewed using biological monitoring and light auditing and by employing an adaptive management approach.

HUMAN-WILDLIFE LIGHTING CHALLENGES

The Light Pollution Guidelines recognise the sometimes-

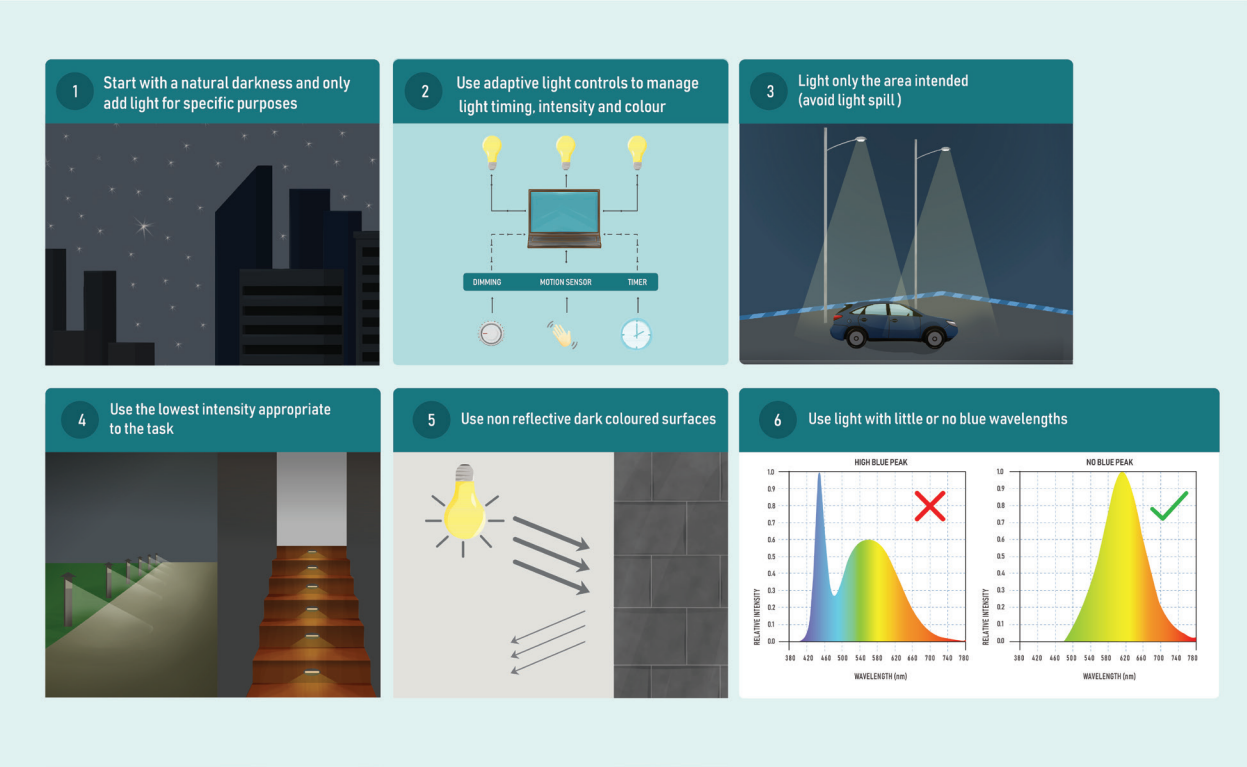

Figure 1. Principles for best practice lighting design. (Commonwealth of Australia, 2020). For colour spectra, see the pdf version, available on-line.

conflicting requirements for human safety and wildlife conservation and do not seek to inhibit the benefits afforded by artificial lighting for humans. Instead the Guidelines note the need to find creative solutions to address both wildlife conservation needs and human safety requirements.

APPLICABILITY OF GUIDELINES

The Light Pollution Guidelines provide specific advice for management of light near important habitat for marine turtles, seabirds, and migratory shorebirds, however the management approach is broadly applicable for any wildlife for which there is evidence that artificial light has an adverse impact. The Guidelines note that artificial light has the potential to impact on a broad range of threatened and migratory species. It is also recognised that incorporating best practice lighting design into all infrastructure will not only have benefits for wildlife, but the environment more broadly through reduced energy consumption. This will in turn provide economic benefit for light owners and managers.

Although the Light Pollution Guidelines were developed within the Australian context, the pervasive nature of light pollution means that the broad principles, process, and technical information provided in the Light Pollution Guidelines can be applied in other countries experiencing similar challenges. On this basis, the Australian Light Pollution Guidelines were presented to 13th Conference of the Parties to the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) in Gandhinagar, India, in February 2020. The Guidelines were endorsed, and the Secretariat requested to promote the Light Pollution Guidelines amongst subsidiary agreements to the CMS, such as the Indian Ocean South East Asian Marine Turtle Memorandum of Understanding (IOSEA).

Australia presented the draft Light Pollution Guidelines at the IOSEA Meeting in Da Nang City, Viet Nam in October 2019 (see Frisch-Nwakanma (2020) in this issue) where the Signatory States supported the Guidelines and agreed to consider applying the Guidelines within national jurisdictions.

The Guidelines are available on the Department of Agriculture, Water and the Environment's webpage (https://www.environment.gov.au/biodiversity/publications/national-light-pollution-guidelines-wildlife).

Literature cited:

Chalastani, V.I., P. Manetos, A.M. Al-Suwailem, J.A. Hale, A.P. Vijayan, J. Pagano, I. Williamson, *et al.* 2020. Reconciling tourism development and conservation outcomes through marine spatial planning for a Saudi Giga-Project in the Red Sea (The Red Sea Project, Vision 2030). *Frontiers in Marine Science* 7: 168. DOI: 10.3389/fmars.2020.00168.

Commonwealth of Australia. 2020. National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and

Migratory Shorebirds. Commonwealth of Australia: Canberra, ACT, Australia. https://www.environment.gov.au/biodiversity/publications/national-light-pollution-guidelines-wildlife. Accessed on April 16, 2020.

Department of Biodiversity Conservation and Attractions. 2017. North West Shelf Flatback Turtle Conservation Program Strategic Conservation Plan 2014–21. Department of Biodiversity, Conservation and Attractions: Perth, Western Australia, Australia. https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/nwsftcp_strategic_conservation_plan_print_.pdf. Accessed on April 16, 2020.

Frisch-Nwakanma, H. 2020. 8th meeting of the Signatories to IOSEA Marine Turtle MoU agrres on new actions to protect turtles. *Indian Ocean Turtle Newsletter* 32: 45-46.

Kamrowski, R.L., C.J. Limpus, J. Moloney & M. Hamann. 2012. Coastal light pollution and marine turtles: Assessing the magnitude of the problem. *Endangered Species Research* 19: 85-98.

Karnad, D., K. Isvaran, C.S. Kar & K. Shanker. 2009. Lighting the way: Towards reducing misorientation of olive ridley hatchlings due to artificial lighting at Rushikulya, India. *Biological Conservation* 142: 2083-2088.

Kyba, C.C.M., T. Kuester, A. Sánchez de Miguel, K. Baugh, A. Jechow, F. Hölker, J. Bennie, *et al*. 2017. Artificially lit surface of Earth at night increasing in radiance and extent. *Science Advances* 3: e1701528. DOI: 10.1126/sciadv.1701528.

Lutcavage, M.E., P. Plotkin, B. Witherington & P.L. Lutz. 2017. Human impacts on sea turtle survival. In: *The Biology of Sea Turtles Volume I* (eds. Lutz, P.L. & J.A. Musick). Pp. 387-409. CRC Press: Washington D.C., USA.

Russart, K.L.G. & R.J. Nelson. 2018. Artificial light at night alters behavior in laboratory and wild animals. *Journal of Experimental Zoology-A. Ecological and Intergrative Physiology* 329: 401-408.

Salmon, M. 2003. Artificial night lighting and sea turtles. *Biologist* 50: 163-168.

Thums, M., S.D. Whiting, J.W. Reisser, K.L. Pendoley, C.B. Pattiaratchi, M. Proietti, Y. Hetzel, *et al*. 2016. Artificial light on water attracts turtle hatchlings during their near shore transit. *Royal Society Open Science* 3: e160142. DOI: 10.1098/rsos.160142.

Wilson, P., M. Thums, C.B. Pattiaratchi, M. Meekan, K. Pendoley, R. Fisher & S. Whiting. 2018. Artificial light disrupts the nearshore dispersal of neonate flatback turtles Natator depressus. *Marine Ecology Progress Series* 600: 179-192.

Witherington, B. & R.E. Martin. 2003. Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches. Florida Fish and Wildlife Conservation Commission FMRI Technical Report TR-2: Jensen Beach FL, USA. http://aquaticcommons.org/id/eprint/115. Accessed on April 16, 2020.