RESEARCH SUMMARY

STAY AWAY FROM THE THE LIGHT! THE EFFECTS OF LIGHT POLLUTION ON HATCHLINGS AND IMPLICATIONS FOR SEA TURTLE POPULATIONS

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The influence of light from coastal development on the orientation of hatchlings and their sea-finding ability has been well documented internationally, but less so within South Asia (see Karnad *et al*., 2009 for a study at Rushikulya, Orissa, India). Hatchlings use the direction that light is coming from and elevation of the beach in relation to the horizon to guide their crawl towards the shoreline, moving away from dark, high silhouettes and towards light, low horizons (Lohmann & Lohmann, 1996; Limpus & Kamrowski, 2013). Artificial lights at night change these visual cues, and hatchlings may become disoriented (crawling in random directions) or misoriented (crawling away from the sea towards the artificial light) (reviewed by Truscott *et al*., 2017). Hatchlings that remain on the beach for longer periods of time are at risk of using the energy reserves needed for their off-shore swim, dehydration, high temperatures after sunrise, and increased likelihood of predation, and mortality rates could potentially reduce population recruitment (see Lorne & Salmon, 2007). Recent research has examined the implications of light pollution on sea turtle hatchlings beyond potential mortality on the beach, and should be taken into consideration when selecting the location for construction of both temporary and permanent hatcheries and the release sites for hatchlings. Nests from which emerging hatchlings are likely to be exposed to light pollution, either direct light or 'sky glow', that will affect their orientation on-land and in-water may need relocation to darker areas of the beach or hatcheries located away from light sources. Hatchlings emerging from nests relocated to hatcheries should be released at locations where on-shore or over-water lights will not interrupt their swim out to sea.

Dimitriadis, C., I. Fournari-Konstaninidou, L. Sourbès, D. Koutsoubas & A.D. Mazaris. 2018. Reduction of sea turtle population recruitment caused by nightlight: evidence from the Mediterranean region. *Ocean and Coastal Management* 153: 108-115.

Dimitriadis *et al*. (2018) examined how hatchling misorientation and mortality on the beach could reduce population recruitment. They assessed light pollution and the orientation patterns of loggerhead turtle hatchlings on five of the six nesting beaches at Zakynthos Is., Greece, including both naturally dark and light impacted locations. At each beach, Dimitriadis *et al*. (2018) measured mean light intensity and movement patterns of hatchlings. The study found a significant difference in light intensity among the five nesting beaches. Hatchling tracks (n=5,967) from nests (n=230) laid on beaches with little or no light pollution demonstrated a seawards orientation. On beaches with the greatest light pollution, hatchlings tracks were skewed in the direction of the brightest light sources; hatchling tracks from 28.5% of nests deviated from a seaward bearing and tracks from 19.0% of nests showed a wider spread of tracks. Of the total reported tracks, 7.5% showed misorientation that would reduce the likelihood of hatchlings entering the sea successfully; the number of 'stray' tracks from a nest was significantly related to its exposure to light pollution. Dimitriadis *et al*. (2018) were the first to quantify the impact of light pollution on sea turtle hatchlings in the Mediterranean, and also to estimate its impact on population recruitment. They conservatively estimated that, from an average clutch of 106 eggs and a hatching success of 73.6%, misorientation due to light pollution would result in fewer than 54 hatchlings per clutch entering the sea on some beaches at Zakynthos Is.. Maintaining and protecting naturally dark beaches for the population was identified as a high priority. Dimitriadis *et al*. (2018) concluded that factors including moon light and beach topography could influence the sea finding ability of hatchlings, and that measures to reduce light pollution and its impact on hatchlings should be assessed and designed at a local scale (see also

Limpus & Kamrowski, 2013; Kamrowski *et al*., 2014).

Thums, M., S.D. Whiting, J. Reisser, K.L. Pendoley, C.B. Pattiaratchic, M. Proiettie, Y. Hetzel, R. Fisher & M.G. Meekana. 2016. Artificial light on water attracts turtle hatchlings during their nearshore transit. *Journal of Herpetology* 29: 568-576.

As lights were believed to influence hatchling orientation in the water as well as on land (see O'Hara, 1980; Salmon & Wyneken, 1987; Witherington & Martin, 1996 in Thums *et al*., 2016), Thums *et al*. (2016) investigated the effects of an artificial light over water on the swimming behaviour of green turtle hatchlings at North West Cape, Ningaloo Reef in Western Australia using miniature acoustic transmitters and a passive receiver array. Emerging hatchlings were collected in the early morning and held during the day until the following night. Acoustic transmitters were glued to the plastron, which enabled hatchlings to be tracked through an acoustic array that began 30m from the low tide mark. The 36 receivers were set up in a 6 × 6 arrangement with each receiver 30m from adjacent receivers. A total of 40 tagged hatchlings were tracked, 20 under ambient light conditions and 20 when a metal-halide light facing the beach was placed on a boat at the edge of the array. Thums *et al*. (2016) found that hatchlings released under ambient light fanned out through the array, with most heading in a north to northwest direction from where they were released at the edge of the water. In the presence of the artificial light, an average of 90% of hatchlings oriented towards the light and spent more time in the tracking array that hatchlings released under ambient light conditions. Although hatchlings attracted to the light eventually swam offshore, the longer time spent in in-shore waters would make them more vulnerable to predators such as reef fishes and sharks (see Gyuris, 1994; Salmon *et al*., 2009).

Truscott, Z., D.T. Booth & C.J. Limpus. 2017. The effect of on-shore light pollution on sea turtle hatchlings commencing their off-shore swim. *Wildlife Research* 14: 127-134.

Truscott *et al*. (2017) added to our understanding of the effect of light pollution on hatchlings that had commenced their off-shore swim, studying the impact of on-shore lights on green turtle hatchlings at Heron Is., Australia. Though at a remote location in the Great Barrier Reef, hatchlings at the study site may be exposed to light pollution and 'sky glow' that originates from a resort and research station on the island. Truscott *et al*. (2017) collected hatchlings at emergence and held them in a bucket for 1-2hr before use in controlled release trials. Groups of on average 80 hatchlings were marked with a unique letter- colour combination on their plastron then released 5m from the waterline at different locations adjacent to a light polluted beach. The researchers, volunteers and observers extinguished personal lights from before hatchlings were released until 5mins afterwards. Researchers then began searching the beaches for hatchlings that had become misoriented and returned to shore, crawling inland toward the light originating from buildings. The authors determined that hatchlings commencing their offshore swim were more likely to become misoriented on moonless nights, as they found 1.0-2.4% of hatchlings (n=1,849) across 67% of all trials (n=24) returned to the beach under these conditions. This threat would further reduce population recruitment.

Cruz, L.M., G.L. Shillinger, N.J. Robinson, P. Santidrian Tomillo & Frank V. Paladino. 2018. Effect of light intensity and wavelength on the in-water orientation of olive ridley turtle hatchlings. *Journal of Experimental Marine Biology and Ecology* 505: 52-56.

Cruz *et al*. (2018) also examined the responses of hatchlings to light pollution after they had reached the water. The authors conducted swimming trials with olive ridley hatchlings from Playa Grande, Costa Rica in artificial pools. Hatchlings were tethered to a central pole and their swimming behaviours in response to the presence of an artificial light was measured using a camcorder. Hatchlings in the pool were allowed to acclimate in total darkness for 5min, then their swimming behaviour for the following 5min (still in total darkness) was recorded to establish a baseline. Following this period, swimming behaviour was recorded as hatchlings were exposed to random combinations of light direction (from true north), light colour (yellow, red and green) and light intensity (0.1-3.3lx to 10.3-45.9lx). After the swimming trials, hatchling orientation relative to true north every 15sec was calculated from the video recordings. Cruz *et al*. (2018) found that both light intensity and wavelength influenced hatchling misorientation towards the artificial lights and away from their orientation in darkness. Misoriented hatchlings eventually corrected their swimming direction after a period of time, but misorientation and disorientation due to light pollution could result in swimming hatchlings remaining in inshore waters for longer than normal and being more vulnerable to predation. Results from studies such as that conducted by Cruz *et al*. (2018) could be used to determine the maximum acceptable light pollution values- both intensity and wavelength- for areas adjacent to a nesting beach. The authors emphasise that behaviour under light varies among sea turtle species, so their results for olive ridley turtle hatchlings may not represent that for other species.

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