

## Coastal Developments and Sea Turtle Conservation: Effect of Artificial Light on Female Nesting Behaviours and Hatchling Post-emergence Migrations

Coastal development includes an array of human activities leading to urbanization and industrialization, changing the landscape of the coastline. Coastal development mainly includes building structures on or near the coast for commercial, residential, recreational, and aesthetic purposes. Although these structures have benefits, primarily political and tourism-related ones, there are many adverse effects in environmental terms. Many turtle-nesting beaches are located close to human-populated areas. Disturbances such as artificial lighting, human presence, shoreline armoring, beach compaction, noise, and pollution not only affect the quality of nesting sites, but also alter the behaviour of both adults and hatchlings.

Sea turtle populations worldwide are severely reduced from historic levels. All seven species of sea turtles are globally threatened today and many conservation and research programmes are underway worldwide to protect them. The status of sea turtles and the need for their protection and population recovery has captured the attention of many government agencies, non-governmental organisations and the general public. Among the global research priorities for sea turtles in the 21<sup>st</sup> century, five categories have been listed: Reproductive biology, biogeography, population ecology, threats and conservation strategies. Under reproductive biology, two meta-questions; 1) What are the factors that underpin nest site selection and behaviour of nesting turtles? and 2) What are the factors important for sustained hatchling production? have been identified as crucial. Both these questions are directly connected to the health of the beaches where females nest and hatchlings emerge.

Among marine vertebrates, sea turtles are the most adversely affected by coastal development, destroying and altering their nesting habitats and increasing artificial light. Artificial lighting near turtle nesting beaches is disruptive to their breeding success. It affects the nest site selection of female turtles and hatchlings' orientation to locate the horizon to move to the ocean after emergence. In the presence of artificial lighting, the adult nesting females are discouraged from nesting. After multiple false crawls, the female will eventually nest in a less optimal site where the survival potential of the embryos could be less. Hatchlings' orientation towards the horizon using visual brightness cues for "sea finding" is disrupted. This can have serious negative consequences for the survival of hatchlings as they may spend time crawling on the beach, increasing the predation risk and wasting the energy storage in their yolk, which is necessary for offshore migration, reducing survival chances. Hatchlings have an innate instinct that leads them to the brightest horizon: the ocean on an undisturbed

nesting beach. Excess lighting from the building on and close to the beach draws hatchlings towards the land.

Five species of sea turtles nest on Sri Lankan beaches. According to the IUCN Red List of Threatened Species, green turtles and loggerhead turtles are Endangered; the hawksbill turtle is Critically Endangered, while the other two species, olive ridley turtle and leatherback turtle, are listed as Vulnerable at a global scale. Until the 1990s, egg poaching and meat consumption significantly threatened sea turtle conservation efforts. Moreover, the hawksbills have been further threatened because of intensive shell trade. In 1977, the conservation treaty CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) banned the tortoiseshell trade. According to the Fauna and Flora Protection Ordinance of Sri Lanka (FFPO, 1938, amended in 1972), capturing, killing, injuring, or possessing sea turtles or their eggs is an offense. Human consumption of eggs and meat and the killing of sea turtles for their scutes have decreased gradually and substantially since 2000, mainly due to public awareness and education programs conducted by the government and non-government organizations, increased punishment given to the offenders, and the publicity received for such acts. However, new threats have become increasingly evident, among which intensive developments in the coastal areas have become a significant threat to sea turtle conservation.

Sri Lanka underwent massive increases in coastal development and an unprecedented tourism boom beyond its expectations following the cessation of nearly three decades of civil war in 2009. The number of international tourist arrivals to Sri Lanka sharply increased from 438,475 in 2008 to 2,333,796 arrivals in 2018, breaking all historical records. Beach holidays have been one of the most favoured tourist attractions; many new hotels have been built along the coastal lines, especially on the southern, southwestern, and eastern coasts, where major sea turtle nesting sites are also located. Using the images from Google Maps, it is possible to assess the coastal developments along the nesting beaches over the years. Several large hotels were built from 2008 to 2018 (Figure 1), along these coastlines; some of them were built on the edge of the beach, ignoring the government-mandated 100 m buffer zone along the south and west coasts and a 200 m buffer zone along the north and east coasts preventing rebuilding in shoreline areas. In some places, the beach area is used for tourist activities. Nesting turtles once had no trouble finding a quiet, dark beach for nesting, but now they must share the beach with tourists, coastal residents and commercial ventures. As development continues around the coastline of Sri Lanka, regulations and monitoring large constructions

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on new undisturbed turtle nesting beaches are important.

Effective management of light pollution requires understanding how the distribution and intensity of light and how light exposure of nesting areas changes over time in response to changing temporal and spatial distributions of coastal development. Some countries have developed turtle-friendly lighting ordinances to mitigate the issue. For example, Hollywood's turtle-friendly lighting ordinance and the Florida Fish and Wildlife Conservation Commission

reduce or eliminate the visibility of interior light from the beach. It is required that exterior lights be mounted at low elevation, shielded, directed down and away from the beach, and have low-wattage amber or red bulbs. To reduce or eliminate the visibility of interior light from the beach, tinted glass, curtains, or blinds must be installed. However, only a few nesting beaches have adopted the ordinance—due to a lack of funds and political will to enforce the regulations properly.



**Figure 1:** Google Map Images of 2008 and 2018 showing coastal developments along main sea turtle nesting beaches in Sri Lanka A) Pasikuda on the East coast B) Panadura on the West Coast and C) Kosgoda, the second largest sea turtle nesting rookeries on the Southwestern Coast of Sri Lanka. Several large hotels were built along these coastlines; some of them were built on the edge of the beach, ignoring the government-mandated 100 m buffer zone along the south and west coasts and a 200 m buffer zone along the north and east coasts, preventing rebuilding in shoreline areas.

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