# Identifying and Mitigating Hatchling Disorientation on Nesting Beaches

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Sea turtle hatchlings use mainly visual cues to find the ocean after emerging from the nest during the night (Lohmann et al. 1997). On nesting beaches, artificial lights can disrupt hatchling seafinding and thus are potentially a major threat. If disrupted between the nest and the ocean, hatchlings may be more susceptible to mortality associated with exhaustion, dehydration, predation, etc. (Whiterington & Martin 2000). Similarly, artificial lights can disorient adult females while they are crawling up the beach to nest (or during the nesting process) (Whiterington & Martin 2000; Deem et al. 2007). Identification and quantification of light impacts on the beaches is an important conservation measure in nesting areas (Whiterington & Martin 2000).

The northern coast of Bahia is a major sea turtle nesting area in Brazil, hosting approximately 6,000 nests per year laid by loggerhead (*Caretta caretta)*, hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea)* and green turtles (*Chelonia mydas*). Conservation activities on nesting beaches in Brazil began in 1982 and continues today, being carried out by Projeto TAMAR (Brazilian National Sea Turtle Conservation Program) (Marcovaldi & Marcovaldi 1999).

Recently, increasing nest numbers have been observed for loggerheads (Marcovaldi & Chaloupka 2007), hawksbills (Marcovaldi et al. 2007) and olive ridleys (Silva *et al*. 2007) in northern Bahia. Concurrently, tourist activities have also increased in the region, resulting in the development of villages and small cities along the coast, in addition to the construction of large resorts in front of nesting beaches (Lyrio 2003). This coastal development has greatly contributed to the increasing occurrence of artificial light on the beaches. In this study, we describe a simple and efficient method to identify emerged nests with hatchlings disrupted by artificial lighting and locate the source of the disruption, with experimental data obtained from several beaches of northern Bahia.

During the nesting seasons of 2006/2007, 2007/2008 and 2008/2009, we investigated hatchling behavior on four beaches in northern Bahia, Northeast Brazil. Two (Busca Vida or BV and Santa Maria or SM) are located in residential condominiums areas, with households on average about 40 m from nests and occupied during the summer, which is the period for the nesting season. BV also has a tourist resort. The other two beaches (Arembepe or AR and Berta or BE) are located in isolated areas, with no inhabitants or direct light sources reaching the beaches. All beaches were daily patrolled at early morning during the nesting and hatchling emergence season (September to April), according to standard methodology for fieldwork, described in Marcovaldi & Marcovaldi (1999), where all nests were marked (Fig. 1A).

To assess and document the impacts of artificial lights in each of the beaches, we examined hatchling tracks from nests in the early morning after primary nighttime emergence occurred. If the majority of observed hatchling tracks went to the ocean, we score the nest as "right". If the majority of observed hatchlings tracks did not go in the direction of the ocean, the nest was scored as "wrong" (Fig. 1A). When live hatchlings were found near the houses in the early morning, we promptly released them. For the three seasons of our study, we observed that on the uninhabited beaches (AR and BE), as expected, 100% of observed nests were scored as "right" (Table 1). However, on the developed beaches (BV and SM), some nests were scored as being "wrong" (Table 1). Overall, SM had a higher rate of "wrong" nests than BV, likely due to the higher density and closer proximity of houses to the nesting beach in SM.

To identify the possible artificial lighting sources causing the observed hatchling disruption, we collected data on the average direction(s) that the hatchlings crawled away from the ocean of each nest (Figure 1B). Using this information, on the following evening, biologists visited the beach with the aim of identifying which light sources attracted the hatchlings. Once indentified, we approached these homes or resorts to speak with the owners or managers, to inform of the impacts of their lights on the turtles and provide them with possible actions to eliminate these impacts. Brazil, there is specific legislation prohibiting the impact of artificial lighting on sea turtle nesting beaches (legislation IBAMA Portaria n° 11 of 30th January 1995 and Bahia's State Law n° 7.034 of 13th February 1997). These laws prohibit the incidence of light on nesting beaches (IBAMA's federal law applies to specific regions of the Brazilian

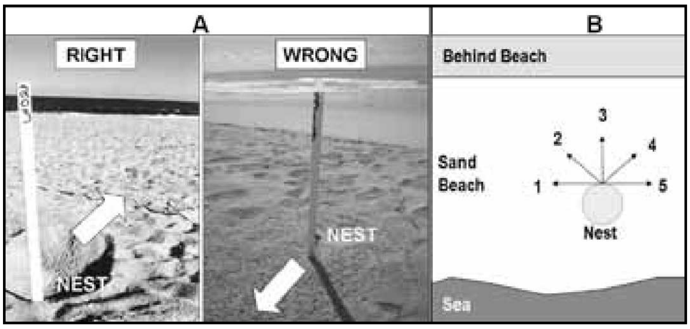


Figure 1. (A) Pictures showing the hatchling's crawls on the sand at the northeast coast of Bahia. RIGHT is the situation when the majority of hatchlings went toward the sea and WRONG when they went on the opposite direction. (B) Schematic representation of the methodology used for the identification of the track directions (1 to 5) of the hatchling's crawls disoriented due to a light pollution sources for each disrupted nest.

| | | BE | AR | SM | BV |
|---|---|---|---|---|---|
| 2006/ 2007 | Total nests | 215 | 158 | 407 | 720 |
| | Nests with hatchling disorientation | 0 | 0 | 20 | 6 |
| | % nests with hatchling disorientation | 0 | 0 | 5 | 0.8 |
| | % light pollution sources identified | n/a | n/a | 100 | 100 |
| 2007/ 2008 | Total nests | 208 | 120 | 406 | 752 |
| | Nests with hatchling disorientation | 0 | 0 | 26 | 18 |
| | % nests with hatchling disorientation | 0 | 0 | 6 | 2 |
| | % light pollution sources identified | n/a | n/a | 100 | 100 |
| 2008/ 2009 | Total nests | 344 | 171 | 530 | 803 |
| | Nests with hatchling disorientation | 0 | 0 | 36 | 18 |
| | % nests with hatchling disorientation | 0 | 0 | 7 | 2 |
| | % light pollution sources identified | n/a | n/a | 100 | 100 |

**Table 1**. Total number of sea turtle nests (including loggerhead, hawksbill, olive ridley and green) laid on Berta (BE), Arembepe (AR), Santa Maria (SM) and Busca Vida (BV), during the 2006/2007, 2007/2008 and 2008/2009 nesting seasons, together with nests observed with disrupted hatchling sea finding.

coast and Bahia state law applies to specific beaches in the state) from any artificial light source in a range of 50 m from the high tide line.

We also georeferenced each nest with disrupted hatchlings, to enable the visualization of satellite images (i.e. available in Google Earth® software). This helped to identify not only the sources of light that caused hatchling disruption of individual nests but also potential hotspots of artificial light affecting many nests (Fig. 2); it also produced maps there were valuable in raising awareness of lightning issues in public meetings with the property owners and managers.

Overall, the method of scoring nests as "right" or "wrong" was simple and quick, and thus easily integrated into the routine morning patrols of beach monitors. Once identified, nests with disrupted hatchling behavior could then be investigated in more detail, and possible sources of artificial light identified.

Despite the low frequency of nests with disrupted hatchlings at SM and BV (<8%), it should be inferred that there is little hatchling disruption by artificial lights along the entire Bahia coast. This is because there is a wide variety of patterns of development behind beaches across the state; we recommend that each beach should be evaluated independently for hatchling disruption.

Our initial success with this simple method of identifying artificial lighting problems on our beaches is promising. However, it may have implications under certain conditions. For instance, moon phase can play a role in hatchling disruption from artificial lighting (Salmon & Witherington 1995). Thus, it may be necessary to continually check for disruption of hatchlings from nests across seasons and perhaps across years, to fully identify problem lighting sources. However, our method is simple and quick enough to implement as a routine measurement during morning patrols.

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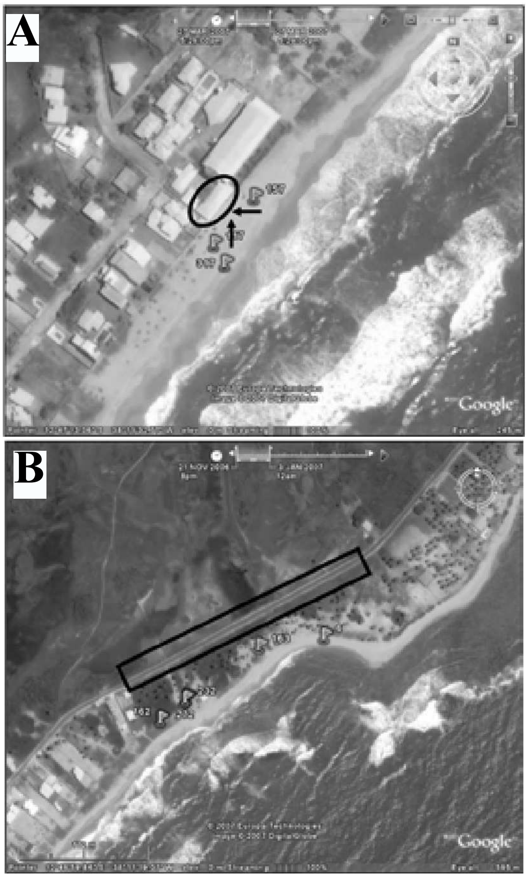


**Figure 2**. Satellite images used for educational purposes showing examples of light pollution affecting sea turtle hatchlings at Santa Maria beach, northeast Brazil. (A) Situation where some nests, each identified as a numbered flag, had hatchlings that crawled toward (arrows) the same small hotel (circled building). (B) A stretch of beach (surrounded by the box) where the light from public street lamps focused direct on nests (flags numbered) on the beach and hatchlings from several nests had crawled toward the street.

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# Indian Ocean Crossing by a Juvenile Hawksbill Turtle

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The following tag report describes the longest recorded migration for a hawksbill turtle (*Eretmochelys imbricata*) and the first trans-Indian Ocean crossing reported for any sea turtle species.

A juvenile hawksbill turtle with tags CA7443/CA7444 was initially captured as part of a larger mark-recapture study in a seagrass and algal feeding area near South Island, Cocos (Keeling) Islands, Indian Ocean (12º 11.528'E / 96º 54.910'S) on 10 Jan 2003. The Cocos (Keeling) Islands is an external territory of Australia. The turtle appeared healthy and measured 54.7 cm curved carapace length, 44.9 cm curved carapace width and weighed 13 kg. On 22 Sep 2008, it was found dead in a fishing net in the Lindi district of Tanzania on the east coast of Africa (approx. 9º 50' S / 39 º 54' E) over 6100 km straight-line distance from its initial capture position (Fig 1.). No other information was available despite contact with the reporter of the information in July 2010 when the tag recovery was first reported. There was no information to indicate if this turtle was a juvenile or adult when found and therefore deduce if this was a breeding or developmental migration. However, based on growth studies of hawksbill turtles from Cocos (Keeling) Islands (Whiting unpublished), it is unlikely this turtle would not have reached mature size during the 5.7 years at large. If this was a movement made by a juvenile turtle it supports previous evidence of long distance and trans-ocean crossings by hawksbill turtles from tag recoveries (Marcovaldi & Filippini 1991; Bellini *et. al*. 2000; Grossman *et. al*. 2007) and genetic studies (Bowan *et. al*. 2007) in the Atlantic. In addition, in 2003 a resident juvenile turtle from the Cocos (Keeling) Islands tracked by satellite telemetry made a westward journey of over 1000 km into the middle of the Indian Ocean before transmissions stopped (Whiting & Koch 2006). This current tag recovery and the previous tracked movement indicate that oceanic movements by foraging hawksbills from the remote Cocos (Keeling) atoll may not be unusual. These records from both the Atlantic and the Indian Oceans indicate that juvenile hawksbill turtles may not always remain in the neritic zone once they appear in shallow foraging areas and have the ability to change foraging locations over very large distances. This tag recovery is a substantial movement record for hawksbill turtles and for the Indian Ocean.

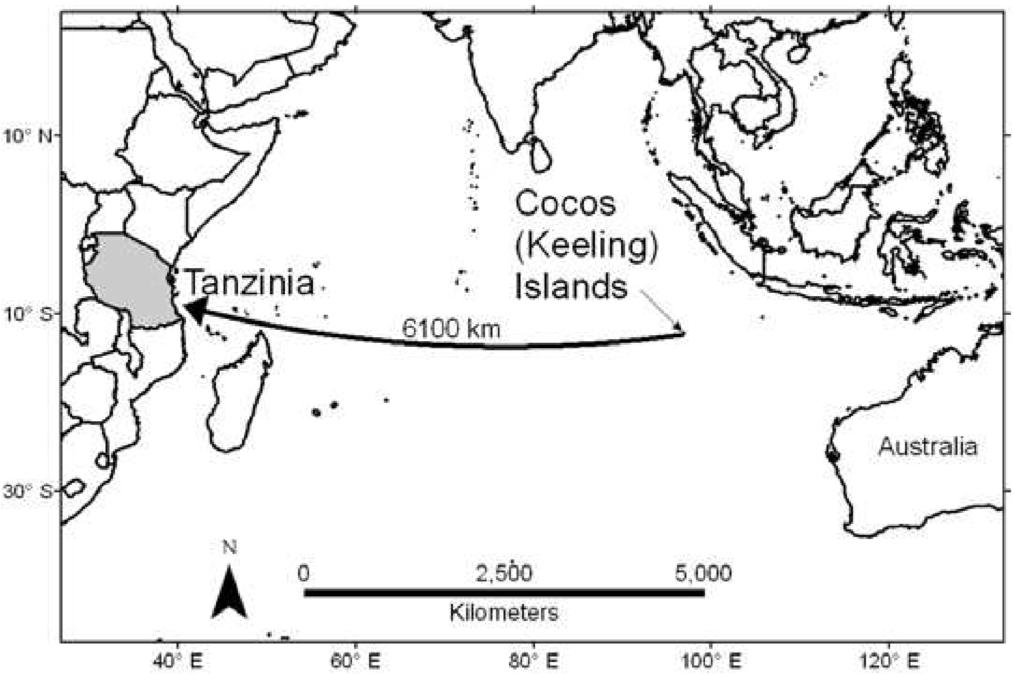


**Figure 1**. Map illustrating the two capture locations and the minimum distance travelled.