

Light Pollution and Marine Turtle Hatchlings: The Straw that Breaks the Camel's Back?

Turtles are reptiles that have been tied to the land for oviposition (egg-laying) since the Order Chelonii first appeared some time in the Triassic period (230-180 mya). The Order Chelonia, to which the marine turtles belong, became established by the Jurassic (180-130 mya). The modern marine turtle families appeared in the Cretaceous (130-65 mya; Lutz and Musick 1996). Only seven species remain today, with six listed as endangered and one as threatened. The reasons for their listings are varied, but all are human-caused: loss of habitat, habitat alteration, illegal and legal fishing, boat hits, pollution, etc.

Over the course of time, these marine species evolved certain methods to perpetuate themselves, including laying eggs on certain sandy beaches that are suitable (1) for laying, incubating, and hatching eggs; (2) for hatchlings to emerge from the sand; and (3) for them to find their way to the sea.

The method for sea-finding by hatchling marine turtles occurs principally at night (Hendrickson 1958; Carr and Hirth 1961; Bustard 1967; Neville et al. 1988; Witherington et al. 1990). The cues for orienting in the proper direction appear to be based upon natural light. There are currently several conflicting views on other cues that hatchlings may use to establish a proper direction to the sea (Witherington and Martin 1996), ranging from different-colored pho-

topigments and oil droplets within the retinas of sea turtle eyes, to shape and color cues, and possibly to the slope of the beach. The view that resource management staff observes in the field at Gulf Islands National Seashore's Florida District will be discussed here.

Since water has a higher albedo than land, in the absence of artificial light the horizon is consistently brighter over the water than it is over the land. The water reflects all heavenly light sources, such as the planets and stars. When present in the evening sky, moonlight is also reflected by the surface of the waters.

For species that evolved to hatch during hours of darkness, a particular ability to head for the brightest horizon perpetuated the species best, as this direction also corresponded

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with the seas the vast majority of the time (Figure 1). To head for darkness resulted in sure death from depredation, exhaustion, or desiccation. As a result, following generations keyed in on this brightest horizon to lead them to the seas, where they would find their niche and repeat the whole process over and over.

In 1879 the invention of the light bulb began a new area of an altered atmospheric condition: light pollution. While humans had been polluting the night sky for several hundred years with candles and lanterns, the over all “candle power” was quite low. Over the years, more and more

incandescent light bulbs, as well as newer and brighter varieties, such as fluorescent, mercury vapor, and high-pressure sodium vapor light bulbs, were installed inside and outside of human dwellings. Businesses and roads are also illuminated with ever-increasing wattage and numbers, creating a glow over populated areas.

Florida’s coastal population has increased from 0.6 million in 1920 to 10.1 million by 1990. With this urban sprawl into the coastal areas came an increased glow in the night sky. Slowly but surely, the horizon above the land became brighter than



Figure 1. A properly oriented hatchling heads for the Gulf of Mexico.

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the horizon over the oceans. In the Pensacola area, only on nights when a three-quarters to full moon has an unobstructed showing in the night sky is there an accurate prehistoric sky, with the brightest horizon being located over the water. This is typically the case for only one to two weeks of the four-week lunar system, with the landward horizon remaining the brightest for two-and-a-half to three of the four weeks of the lunar phase. The actual nights with sufficient natural light available are lower due to cloud cover blocking the moonlight on some nights.

In the decade just past, the Pensacola area saw its construction work force increase 46% from 10,539 in 1990 to 15,391 in 2000 (Livingston and Pooley 2000). Escambia County has grown from a population of 233,794 in 1980 to 282,604 by 1997, a 21% increase. Adjacent Santa Rosa County has grown from 55,988 to 114,481 over the same time frame, a 104% increase (Oregon State University Information Services 1998). But it is not just lights near the beach that are the problem. Lights located inland for several miles emit a collective glow that is easily observed from the local beaches. Some of the worst of the inland collective offenders are gasoline stations. Each station has anywhere from 12 to 36 400-watt metal halide bulbs used to illuminate the store area. Metal halide bulbs are extremely bright and smaller versions

are currently being used in the aquarium industry to maintain corals, as the bulbs can simulate sunlight. Other large structures such as shopping malls, condominiums, and sports fields also emit large amounts of light. The lights from several thousand single-family homes also contribute to the illumination of the night sky.

There are currently six large collective glows on the northern horizon observed from the park. They are Perdido Key to the west, Pensacola Naval Air Station and Pensacola to the north, Gulf Breeze and Navarre to the northeast and Navarre Beach to the east.

As a result, marine turtles that hatch under these unnatural lighting conditions continue to orient towards the brightest horizon, since their evolutionary agenda is still locked in an era when "bright" was the way to go. As a result, approximately half the nests in the park experience a high level of hatchling disorientation, and the hatchlings orient and crawl in the wrong direction. In 1999, 33 of 65 nests (51%) that hatched had levels of disorientation where at least 25% of the hatchlings emerging from the nest cued in on the wrong direction. In 2000, 26 of 58 nests (45%) that hatched were disoriented.

At Gulf Islands National Seashore's Florida District, this alteration of the night sky has been plaguing marine turtles for the last five

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years. It may have been a problem before that, but accurate monitoring of individual turtle nests has only been going on for the last five to seven years.

The problem was exacerbated by the destruction of the primary dune field in 1995 from Hurricane Opal. These dunes and associated vegetation blocked ambient light levels from the north to some degree.

The park inventories for marine turtle nests every year from May 15 until late September. The federally threatened loggerhead turtles (*Caretta caretta*) are the most common, with a few federally endangered green turtles (*Chelonia mydas*) as well. In the past two years, two new species have been documented as nesting in the park. A Kemp's ridley turtle (*Lepidochelys kempi*) nested in the park in 1998, and the summer of 2000 witnessed a leatherback turtle (*Dermochelys coriacea*) nesting in the park. Volunteers and resource management staff patrol the beaches every morning just after dawn on all-terrain vehicles. Over 35 km of beach are patrolled in the park. The tell-tale crawl of the female turtles is easily found on most morning patrols. However, every year a few nests are missed due to the effects of weather obscuring the crawls before the patrols can be completed.

As a result of light pollution levels, the park has been forced to take precautionary measures to guard against hatchling disorientation events. Dif-

ferent ideas to mitigate light pollution have been used by staff in the park's resource management division over the years. For a short period of time, the park attempted to use a black erosion-control fabric fence. It was placed behind the nest and strung out in a V pattern from behind the nest towards the Gulf of Mexico. The fabric simulated a dark landward sky by blocking out the artificial light at hatchling eye level. The problem was that the ends of the V pattern could not extend into the Gulf of Mexico, due to wave action. Once the hatchlings passed the end of the V, they would cue in on the brightest horizon and turn and head the wrong way.

Efforts are now directed at listening to nests on morning patrols by simply placing an ear to the ground above the egg chamber. If the hatchlings are active in their digging effort, the sound is not easily missed. The monitor takes care so that the nest is not crushed in this effort. If the hatchlings are heard and sounds are very loud, hatching typically occurs within one or two evenings. However, due to the fact the hatchlings do not dig continuously in their effort to emerge from the sand, hatchlings can be close to emerging and can go undetected.

"Coning" is also looked for on patrols. This is when a small depression appears in the sand above the egg chamber. This typically occurs 12 to 36 hours before the hatchlings

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emerge from the nest. It is the result of the hatchling chamber collapsing as it approaches the surface.

Currently the park uses numerous volunteers and resource management staff to “nest sit” when hatching is near. This “timing” is rudimentary at best, since incubation times can vary as much as 10 days for nests laid under similar conditions. Interest by park volunteers can wane after two or three nights of a nest not hatching.

Screening the nests with cages that detain the hatchlings is also part of the effort. But the egg chamber location must be known for this method to be used. As the hatchlings emerge under the screen, they are detained until a pre-dawn patrol releases them. While this method prevents disorientation from occurring, it can expose the hatchlings to several hours of detention during which they expend critical energy in continual escape attempts until they are released from under the cage.

When there is little or no moon, hatchlings that emerge must be moved closer to the surf by the park staff. The hatchlings are then typically released behind a small berm where the beach angles towards the surf at about 10-20 degrees. The

berm blocks the brighter northern horizon to a sufficient degree, the hatchlings crawl into the Gulf and then orient themselves so as to swim into the waves (Salmon and Lohmann 1989; Lohmann et al. 1990; Wyneken et al. 1990). This leads them offshore to their post-hatching migration routes.

Marine turtles are currently a heavily managed species at Gulf Islands National Seashore. Since evolution occurs over geological time scales, in the near future no evolutionary adaptation by marine turtles to light pollution is anticipated. There is no immediate reason to suspect that human populations will decrease or lose their need to illuminate the night sky. As a result, marine turtle hatchlings will continue to go in the wrong direction after emerging from their nests. It will take a large commitment by park staff and volunteers to be at the nests when hatchings occur so as to interfere with the unnatural cues provided by the artificial lights to the hatchlings. Current as well as future biologists and volunteers have a great deal of night work ahead of them if these species are going to survive.

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