Title

Dark beaches – FDOT's approach to resolving coastal roadway lighting and its impacts to adjacent sea turtle nesting beaches

Authors

Broadwell, Ann
Salmon, Dr. Michael
Ellis, Dr. Ralph

Publication Date

2001-09-24

DARK BEACHES – FDOT'S APPROACH TO RESOLVING COASTAL ROADWAY LIGHTING AND ITS IMPACTS TO ADJACENT SEA TURTLE NESTING BEACHES

Ann Broadwell, Florida Department of Transportation, District Four Office, 3400 West Commercial Blvd, Fort Lauderdale, FL 33309, Phone: 954-777-4325, Email: ann.broadwell@dot.state.fl.us

Dr. Michael Salmon, Department of Biological Sciences, Florida Atlantic University, 777 Glades Road, Boca Raton, Florida 33431, Phone: 561-297-2747, Fax: 561-297-2749, Email: salmon@fau.edu

Dr. Ralph Ellis, College of Civil Engineering, University of Florida, Phone: 352-392-3730, Email: relli@ce.ufl.edu

Abstract: The effects of artificial lighting on nesting female sea turtles and their offspring have been well documented in Florida for years. While federal and state regulatory agencies have pursued dark beaches to protect sea turtle habitat, Florida's coastline has continued to develop and degrade nesting beaches with artificial light. Currently, Florida Department of Transportation (FDOT) Design Standards do not take into account the biological conditions of adjacent properties. Transportation-related impacts caused by coastal roadway lighting affect sea turtle behavior by deterring nesting females from utilizing an otherwise suitable beach for nesting and incubation purposes. Coastal roadway lighting affects sea turtle habitat by forcing the nesting female to utilize inferior beaches that may not provide the best environment for hatching and emergence success of the clutch. Lastly, coastal roadway lighting impacts sea turtle populations when emerging hatchlings are attracted landward toward light sources. These 'disoriented' hatchlings usually die from predation, dehydration, heat exposure after sunrise, or getting crushed by vehicles. Hatchlings depend on visual cues from the beach in order to find their way to the ocean. With fewer hatchlings successfully making it to the ocean, fewer hatchlings make it to adulthood. This paper will discuss the development of Sea Turtle Lighting Zones, the proposed changes to the FDOT Lighting Standards for these zones, and the use of innovative lighting technology to illuminate the road for the traveling public and at the same time reduce impacts to adjacent sea turtle nesting beaches.

Introduction

Five species of sea turtles (loggerhead, *Caretta caretta*; leatherback, *Dermochelys coriacea*; green turtle, *Chelonia mydas*; hawksbill, *Eretmochelys imbricata*; and Kemp's ridley, *Lepidochelys kempi*) are found in U.S. coastal waters. Of these, four species (all but the Kemp's ridley) nest on U.S. shores. Loggerheads (the second largest population of this species in the world) place about 90% (70,000 annually) of their nests on the east coast of Florida. In addition, about 2000 green turtles, and more than 120 leatherbacks, also nest on Florida's beaches each year (Meylan, Schroeder, and Mosier 1995).

"Photopollution" (the negative influence of stray, artificial lighting on the survival and /or reproductive activities of nocturnally active organisms) is a major factor degrading sea turtle nesting beaches in Florida. It arises as a consequence of 40 years of intense immigration to the state, and settlement along its coastline. Stray light from homes, businesses and municipalities reaches the beach where it repels gravid turtles that nest at night. Today, most Florida sea turtles nest within the few remaining areas where light levels are low. However, a significant minority continues to place nests at sites where the beach is exposed to lighting. At such sites, extraneous lighting affects their hatchlings that emerge from nests at night. Hatchlings depend primarily upon visual cues to locate the ocean. Artificial lighting can either prevent turtles from detecting natural cues or, in extreme cases, attract them landward to the light source. Attracted hatchlings usually die from predation [capture by raccoons and foxes], dehydration, crushing by cars on roadways, or heat exposure after sunrise (Salmon 1998).

Habitat alterations associated with FDOT coastal highways contribute to many beach lighting problems. In 1998, FDOT entered into a research study with Florida Atlantic University (FAU) that would address the impacts of coastal roadway lighting on adjacent sea turtle nesting beaches. Originally, the purpose of this study was to (i) identify coastal roadway lighting problems, (ii) determine how they can be corrected, and (iii) use this information to develop new and improved lighting standards for roadway design engineers, coastal communities and utility companies. It has since been expanded to include an embedded roadway lighting demonstration project as well as an evaluation of the safety and roadway user response to embedded roadway lighting.

The purpose of this paper is to provide an overview of each FDOT sponsored research study. All studies are works in progress. The final report is scheduled for completion in April 2002.

Study 1: Coastal Roadway Lighting Impacts on Nesting Endangered and Threatened Marine Turtles and their Hatchlings

The first objective for this study was to conduct a coastal lighting survey of Florida's roadways. FDOT coastal roadways were inspected in order to identify existing lighting problems. Local conditions such as presence/absence of lighting system, presence/absence of sea turtle nesting activity on the adjacent beach, and adjacent land use were recorded. The Sea Turtle Lighting Zones were established from the survey. Coastal roadways will be classified into four types:

- Type I – Roadway is without lights and the surrounding area (as well as the adjacent beach) is dark.
- Type II – Roadway is furnished with lighting fixtures, some or all of which are visible at the beach. Other lighting is rarely present.
- Type III – FDOT luminaires and other sources illuminate the beach, either directly or indirectly. Modification of roadway lighting is likely to significantly reduce this illumination, but in some areas, is unlikely to render the beach totally dark.
- Type IV – Lights from streets and roadways make a relatively insignificant contribution to an already serious lighting problem (caused by extensive coastal development).

The information from this objective will be used to develop a geographically referenced database. This database will be displayed as a map and will provide information on existing roadway lighting conditions, the Sea Turtle Lighting Zone classification and the alternative lighting standards that a design engineer would be allowed to use in that particular Sea Turtle Lighting Zone. It will be part of the Florida Geographic Database Library (FGDL).

In order to determine what modifications to existing lighting fixtures and FDOT Design Standards are necessary, several roadways on the east and west coast were selected as experimental sites. These sites were used to document hatchling disorientation before and after modifications were made to the light source. Disorientation occurs when hatchlings can not maintain a constant directional movement toward the ocean because of a light source interfering with the their sea-finding ability (Witherington and Martin 1996). Modifications to light sources included shielding of fixtures, repositioning fixtures, and turning off lights. It was determined that some of these solutions were beneficial to the turtles but did not consider public safety. Filtered lens, developed by Florida Power and Light Company (FPL), were also tested. The filters were designed to exclude the transmission of the shorter light wavelengths, allowing the longer light wavelengths to be transmitted to the environment. Sea turtles are most sensitive to short light wavelengths. It was thought that it might be possible to illuminate coastal roadways for humans with spectral hues that the turtles ignore (Cowan and Salmon 2000). Both adult nesting females and hatchlings were studied using the filtered lens on streetlights in Palm Beach County, Florida that were located on a Type II coastal roadway. The FDOT study indicates that filtered lighting is ignored by nesting loggerheads but cautions that other species may respond differently (Pennell and Salmon 2000). Comparative studies have shown that both spectral sensitivity and perception vary among hatchling species (Witherington 1992; Lohmann et al. 1996). This may persist into adulthood. Similar conclusions were drawn concerning loggerhead hatchling response to filtered lighting (Cowan and Salmon 1998).

Study 2: Design, Installation and Maintenance of an Embedded Roadway Lighting System for Turtle Nesting Protection

FDOT has furthered its research efforts by funding a demonstration project that allowed for the research, design, installation, and maintenance of an embedded roadway lighting system. The system would be utilized in the summer when sea turtle nesting activity occurs. It is interesting to note that marine turtle nesting activity is seasonal. Modifications to existing lighting systems and the design of new lighting systems along coastal roadways should take this into consideration. This type of lighting system is under consideration for use in the Sea Turtle Lighting Zones.

The location of the embedded roadway lighting system is a Type II one half-mile stretch of State Road A1A in Boca Raton, Florida. The site was selected for the following reasons - the presence of vegetation between the road and the beach, known sea turtle nesting activity on the beach, documented hatchling disorientation events, and a desire by the City of Boca Raton to correct the problem. The product selected for installation is an illuminated raised pavement marker (RPM). The unit contains light emitting diodes (LED) that are energized by induction. A low voltage cable with energy nodes is trenched into the asphalt. The trench is resealed and

the illuminating RPM is placed on top of the energy node. These units assist in delineating the pavement markings and were installed to enhance the centerline and outside lane markings. In addition to illuminating the pavement markings, low-level bollards were installed 3 feet from the edge of the paved shoulder. These louvered units disperse light horizontally across the pavement. This type of lighting should transfer bright, elevated light sources from tall poles to the street itself, thereby placing the light where it is needed while reducing its scatter to other areas of the environment (Hughes and Salmon 2001).

Study I has been supplemented to include beach surveys to determine the effects of low level lighting on adjacent sea turtle nesting beaches. Arena assays or staged hatchling emergences will be conducted on the adjacent sea turtle nesting beach. The experimental design allows for three light conditions to be researched—street lights on, embedded lights off; street lights off, embedded lights on; street lights off, embedded lights off. These arena assays are being conducted in the summer of 2001.

Study III: Evaluation of the Safety and User Response to Embedded Roadway Lighting Systems on an FDOT Demonstration Project

In order to evaluate the safety aspects of the embedded roadway lighting system that was installed summer 2001, FDOT entered into a research agreement with the University of Florida (UF). It is essential that the embedded roadway lighting system provide for the safety of the motorist, bicyclists and pedestrians.

A survey instrument was designed to obtain input from users of SR A1A. Motorists, pedestrians and cyclists were asked to give their opinion on the light levels of the new system, the location of the low level light fixtures in reference to safety, and whether or not impacts to sea turtles should be taken into consideration when designing a roadway lighting system. Approximately 2000 surveys were distributed in August 2001. Currently, UF is collecting and analyzing the data on the returned surveys. The results of the UF study will assist in determining just how innovative the traveling public will allow FDOT to be when it comes to alternative roadway lighting.

Conclusion

The above referenced research studies will provide FDOT with the information necessary to resolve coastal roadway lighting and it's impacts on sea turtle nesting beaches. Revising lighting standards within the Sea Turtle Lighting Zones will allow civil engineers to consider the biological conditions of adjacent property when designing roadway projects.

Biographical Sketch: Ann Broadwell has worked for the Florida Department of Transportation for 9.5 years as an Environmental Specialist. Ann has conducted environmental impact reviews to ensure NEPA compliance on Roadway and Bridge projects. She has worked on Environmental Resource Permitting activities for the US Highway 1 South project to the Florida Keys; this included the construction of the upfront mitigation activities for the USFWS Crocodile Refuge restoration project. Ann's interest in Sea Turtle Biology is a carryover from Graduate School, where her Master's Thesis was on Beach Renourishment and its effects on Loggerhead sea turtle hatchlings. She graduated from Florida Atlantic University with a Master of Science Degree, with an emphasis on Marine Biology.

References

Cowan, E. and Salmon, M. 1998. Influence of filtered lighting on the orientation of hatchling loggerhead turtles, *Caretta caretta* L. Unpublished report submitted to Florida Department of Transportation.

Hughes, L. and Salmon, M. 2001. Influence of embedded roadway lighting on the orientation of hatchling loggerhead turtles, *Caretta caretta* L. Unpublished report submitted to Florida Department of Transportation.

Lohmann, K.J., Witherington, B.E., Lohmann, C.M.F., and Salmon, M. 1996. Orientation, navigation, and natal beach homing in sea turtles. In: Biology of Sea Turtles, pp.107-136 (P.L. Lutz and J.A. Musick, eds.) CRC Press, Boca Raton, Florida, USA.

Meylan, A., Schroeder, B., and Mosier, A. 1995. Sea turtle nesting activity in the State of Florida 1979-1992. Florida Marine Research Publications No. 52. 51pp.

Pennell, J. and Salmon, M. 2000. Effects of filtered lighting on nest site selection by loggerhead sea turtles, *Caretta caretta* L. Unpublished report submitted to Florida Department of Transportation.

Salmon, M. 1998. Impacts of coastal roadway lighting on endangered and threatened sea turtles. Unpublished report submitted to Florida Department of Transportation.

Witherington, B.E. 1992. Behavioral responses of nesting sea turtles to artificial lighting. Herpetologia 48 (1), 31-39.

Witherington, B.E. and Martin, R.E., 1996 Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches. Florida Marine Institute Report TR-2. 73 pp.