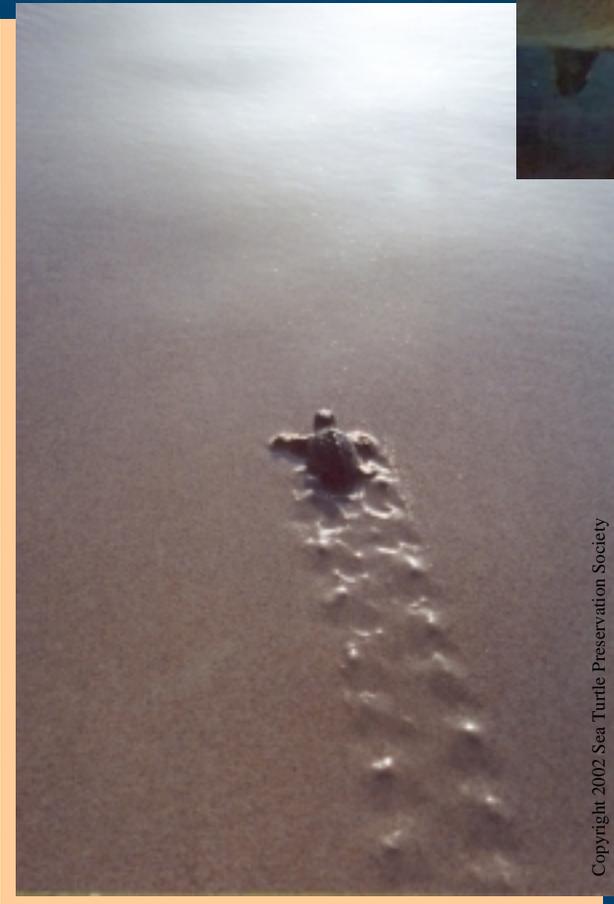
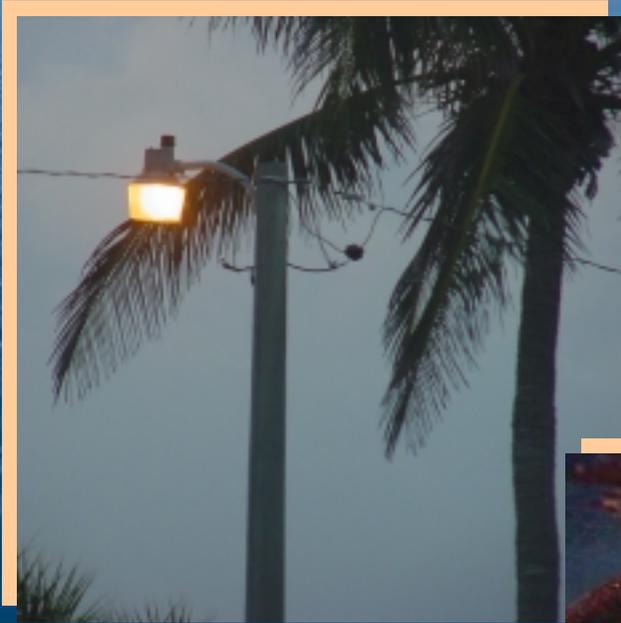


Coastal Roadway Lighting Manual



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A handbook of practical
guidelines for managing
street lighting to minimize
impacts to sea turtles

May 2002

COASTAL ROADWAY LIGHTING MANUAL

A HANDBOOK OF PRACTICAL GUIDELINES FOR MANAGING STREET LIGHTING TO MINIMIZE IMPACTS TO SEA TURTLES

May 2002

Revised by Florida Power & Light Company in consultation with Ecological Associates, Inc., Florida Fish and Wildlife Conservation Commission, US Fish and Wildlife Service, Florida Department of Transportation, and the Florida Department of Environmental Protection.

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USER'S GUIDE

This section briefly describes the intent of the Coastal Roadway Lighting Manual, provides an overview of its content, and directs users to those sections of the manual that may be of greatest immediate use and/or interest. **PLEASE TAKE A FEW MOMENTS TO READ THROUGH THE QUESTIONS BELOW BEFORE PROCEEDING TO THE BODY OF THE DOCUMENT!**

1. What is the Intent of the Coastal Roadway Lighting Manual?

Florida's beaches serve as important nesting habitat for several species of threatened and endangered sea turtles. Artificial light on or near nesting beaches can negatively affect the nesting process by interfering with normal nocturnal behaviors of sea turtles. Streetlights contribute to this problem.

The impetus for the Coastal Roadway Lighting Manual was an accumulating record of impacts to sea turtles from streetlights and an apparent lack of understanding and/or resources needed by lighting custodians to implement effective solutions. By providing practical guidelines and identifying resources needed to reduce impacts to sea turtles, this manual is designed to facilitate and standardize light management efforts along coastal roadways in Florida.

2. Am I Required to Take Any Action as a Result of This Manual?

The Coastal Roadway Lighting Manual does not impose any new regulations nor does it establish time frames for bringing streetlights into compliance with applicable lighting regulations. It is merely a tool to assist interested parties in resolving identified street lighting problems.

3. Why Should I Be Concerned About Streetlights That Shine on the Beach?

Lights shining on the beach have the potential to interfere with the natural nesting and/or sea-finding ability of sea turtles and may be in violation of local, state and/or federal laws and regulations. The party responsible for the operation of lights causing problems for sea turtles could be subject to fines and other penalties. Good faith implementation of appropriate light management techniques, as presented in the Coastal Roadway Lighting Manual, should substantially reduce exposure to this liability.

4. *Must I Compromise Roadway Safety To Protect Sea Turtles?*

Fortunately, street lighting can generally be managed in a manner that minimizes the potential for impacts to sea turtles while still providing for adequate nighttime highway safety. Technological advances presented in the Coastal Roadway Lighting Manual provide flexibility in accommodating various street lighting interests under different local highway conditions and environmental settings.

5. *Who is This Manual Intended to Serve?*

The Coastal Roadway Lighting Manual was developed with the following audiences in mind:

- Utility customer service representatives,
- Utility field personnel,
- Traffic planners and engineers,
- Environmental planners and managers,
- Regulators,
- Code enforcement officers,
- Conservationists, and
- Others involved in roadway light management.

6. *Do I Need a Background In Sea Turtle Biology to Use This Manual?*

The Coastal Roadway Lighting Manual is intended to serve those with no prior experience dealing with lighting issues as they relate to sea turtles. The manual contains basic information on how light affects both adult and hatchling sea turtles, but an understanding of that process is not essential to achieving effective light management. Step-by-step guidelines are provided for determining if a light is likely to be a problem for sea turtles and for resolving previously and newly identified problems.

7. *I Don't Have Time to Read the Entire Manual Right Now! Where Should I Start?*

The Coastal Roadway Lighting Manual includes a step-by-step approach to effective light management. A variety of background and supporting information is also included. This supporting information may not be of immediate interest to all users. The index below helps guide users to those sections of the manual of greatest immediate need or interest.

If you are interested in determining what alternatives are available for resolving street lighting problems, go to Page 38.

If you have a basic understanding of light management objectives and would like to select the best alternative for an identified street lighting problem in your community, go toPage 49.

If you would like to review the basic goals of effective streetlight management, go to Page 30.

If you would like an overview of the step-by-step approach to effective streetlight management, go to Page 32.

If you would like to know how to determine if a particular streetlight is likely to cause a problem for sea turtles, go to Page 27.

If you are interested in learning more about how lights impact sea turtles, go toPage 5.

If you are interested in reviewing the various public safety, regulatory, and environmental issues germane to streetlight management, go to Page 11.

If you would like to review the approach taken during the development of this manual or a list of project participants, go to Page 1.

8. *Who Can I Contact if I Have Questions Regarding the Content of This Manual?*

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9. *How Can I Obtain Additional Copies of the Coastal Roadway Lighting Manual?*

Copies of the Coastal Roadway Lighting Manual, as well as periodic updates, may be obtained electronically from the Florida Fish and Wildlife Conservation Commission through their web site at:

<http://floridaconservation.org/psm/turtles/manual.pdf>

ACKNOWLEDGEMENTS

This document was originally prepared by *Ecological Associates, Inc. (EAI)* of Jensen Beach, Florida under a contract administered by *Florida Power & Light Company*. The manual was a collaborative effort involving the electric industry, transportation officials, regulators, biologists, and local government sponsors with interests in improved light management. EAI and FPL would like to thank all project participants for their support and assistance on the original and revised versions of the manual, including:

Florida Fish and Wildlife Conservation Commission

•

Florida Department of Environmental Protection

•

U.S. Fish and Wildlife Service

•

Florida Department of Transportation

•

General Electric Lighting Systems, Inc.

•

The City of Delray Beach

•

The City of Fort Lauderdale

•

The City of Hallandale

•

The City of Hollywood

•

The Town of Longboat Key

•

The City of St. Augustine Beach

•

The City of Venice

•

Manatee County

•

Palm Beach County

•

Sarasota County

•

St. Johns County

•

Volusia County

CHAPTER 1

INTRODUCTION

Purpose

In Florida, many important arterial roadways are located near the shore. These roads provide beach access to millions of residents and tourists as well as scenic routes between coastal towns and cities.

Florida's beaches provide important nesting habitat for five species of threatened or endangered sea turtles (Meylan et al., 1995). Activities that directly harm sea turtles, interfere with their essential nocturnal behaviors, or degrade nesting habitat are prohibited by law under the U.S. Endangered Species Act (ESA) of 1973 and Florida Statutes.

The proximity of lighted roadways to sea turtle nesting beaches presents an environmental dilemma in Florida. Normal behavior of adult nesting female and hatchling sea turtles can be altered by artificial light sources near the beach. This can lead to reduced nesting by adults and an inability of hatchlings to properly orient to the sea after leaving the nest. Both effects are undesirable. Interference with the sea-finding ability of hatchlings is of particular concern, because it can result in increased mortality of these threatened and endangered species.

Under increasing pressure from the U.S. Fish and Wildlife Service (USFWS) and the Florida Fish and Wildlife Conservation Commission (FWC), local communities are searching for ways to minimize lighting impacts to sea turtles. For many years, street lighting problems were dealt with on a case-by-case basis. Different solutions were developed independently for similar problems in geographically distant locations. Some solutions were effective, while others were not. The intent of this manual is to provide a standard and practical approach to light management on Florida's coastal roadways. The guidelines and resources contained herein will facilitate the timely selection and implementation of lighting modifications that, when properly applied, can reasonably be expected to reduce the potential for future impacts.

Approach

Guidelines and alternative lighting recommendations contained in this manual were the collaborative effort of a **Technical Working Group** (TWG). Participants on the TWG (Appendix A) consisted of lighting experts, traffic engineers, public safety personnel, utility customer service managers, biologists, and regulatory agency personnel representing the following:

- Florida Power & Light Company (FPL),
- FWC,
- USFWS,
- Florida Department of Transportation (FDOT),
- Delray Beach Police Department,
- General Electric Lighting Systems, Inc., and
- Ecological Associates, Inc. (EAI).

The TWG considered public safety, economic, social, and conservation issues as it evaluated potential lighting solutions. Rather than advocating a single solution for all lighting problems, the focus was on providing a suite of lighting alternatives to provide flexibility in dealing with unique local conditions. Both existing and new technologies were reviewed and evaluated.

A **Steering Committee** was formed to support the TWG (Appendix B). This committee was comprised of representatives from county and municipal governments with interests in the development of effective solutions for street lighting problems in their communities. Members of the committee assisted in identifying issues of local concern, reviewed and provided recommendations on work products, served as liaisons between the TWG and their respective governing bodies, and contributed to the cost of manual production.

Because of the complexity of issues involved with street lighting and the diverse social and environmental settings around the state, satisfactory resolution of roadway lighting and endangered species conflicts can, at times, be difficult. This manual does not offer a panacea for all lighting problems. Rather, it provides a practical approach to addressing problem lights in a manner that is likely to reduce the potential for impacts. In most cases, recommended management techniques will completely eliminate a lighting problem. However, in other situations, additional light management efforts may be needed if the “corrected” problem light continues to interfere with the behavior of sea turtles.

Misconceptions abound as to what constitutes a satisfactory “fix” for lights causing problems for sea turtles. The involvement of recognized experts in the fields of roadway lighting and sea turtle conservation was intended to lend authority to the guidelines and alternative solutions presented in the manual. All members of the TWG and Steering Committee had an opportunity to review and comment on the original manual and the TWG participates in subsequent updates.

When properly applied, the light management strategies contained in this document are endorsed by FWC and USFWS, the regulatory agencies responsible for sea turtle conservation and recovery programs in Florida and the U.S., respectively.

Objectives

There are many types of lights, other than streetlights, that cause problems for sea turtles on Florida's beaches. Clearly, all sources of artificial light near the beach must be properly managed. A recent publication by Witherington and Martin (2000), *Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches*, provided an in-depth look at this broader issue and offered practical solutions for effective light management. However, streetlights differ from most other types of public and private lights, in that they perform a unique public function. Complex issues of highway safety, regulatory constraints, and liability are involved in the satisfactory resolution of associated lighting problems. Thus, street lighting management requires a special understanding and approach that was not previously articulated. That is the reason for this manual. It is intended to serve as a companion document to the Witherington and Martin (2000) publication.

The primary objectives of the TWG during development of the Coastal Roadway Lighting Manual were to:

- 1) Review the various public safety, social, regulatory, economic, and environmental issues related to street lighting,
- 2) Review and evaluate existing, as well as new and innovative, technologies for resolving street lighting problems,
- 3) Establish clear and concise guidelines for effective streetlight management using best available technology, and
- 4) Within the framework of the controlling issues identified in No. 1 above, prepare a manual that provides a practical and standard approach to addressing coastal roadway lighting problems in Florida endorsed by USFWS and FWC.

This manual is intended to serve a variety of users, including but not limited to:

- Utilities (field personnel and customer service representatives).
- Road departments (traffic planners and engineers).
- Municipalities (code enforcement and environmental managers).
- Regulatory agencies.
- Conservation groups.

The previous lack of basic guidelines for streetlight management often resulted in duplication of effort, inadequate resolution of identified problems, delays in implementation of effective solutions, and/or unnecessary expense. These situations were extremely frustrating and frequently led to an adversarial climate between those requiring that lighting be modified and those responsible for affecting a solution. This project is intended to foster

a more cooperative working relationship among lighting customers, lighting custodians, regulators, and conservationists.

CHAPTER 2

SUMMARY OF EFFECTS OF COASTAL LIGHTING ON SEA TURTLES

Many animals, including sea turtles, rely on celestial light for visual orientation and/or the timing of periodic behavior. Artificial light that interferes with these essential behavioral systems is termed photopollution (Verheijen, 1985). Unlike chemical pollutants, errant artificial light is not toxic. Nevertheless, it can have profound effects on the survival of animals that rely on accurate light information to initiate or guide critical biological activities (Witherington, 1997).

Light cues figure prominently in the reproductive behavior of sea turtles. Errant lighting on or near nesting beaches introduces misinformation to turtles during vital phases of the reproductive process (Witherington and Martin, 2000; Lohmann et al., 1997).

Effects on Adults

Sea turtles in Florida nest almost exclusively at night. This adaptive behavior protects the female from would-be predators and from over heating.

In summarizing our current scientific understanding of how artificial light affects sea turtles, Witherington and Martin (2000) concluded that the most clearly demonstrated effect of artificial lighting on adults is to deter nesting females from emerging from the ocean. In field experiments at undeveloped nesting beaches, both loggerhead and green turtles showed a significant tendency to avoid stretches of brightly illuminated beach (Witherington, 1992). Additionally, many researchers have noted a relationship between the amount of lighted beach development and sea turtle nest densities. For example, Mattison et al. (1993) noted that emergences of nesting turtles in Broward County, Florida were reduced in areas where lighted piers and roadways were near the beach. In areas where a glow of artificial light is present behind the dune, loggerhead turtles prefer to nest in the darker areas silhouetted by tall buildings and dune vegetation (Salmon et al., 1995).

Effects on Hatchlings

Although there is a tendency for turtles to prefer dark beaches, many do nest on lighted shores. As noted by Witherington and Martin (2000), in doing so, they place the lives of their hatchlings at risk. That is because artificial lighting can impair the ability of hatchlings to properly orient to the ocean once they leave their nests.

Hatchling sea turtles exhibit a robust sea-finding behavior. A direct and timely migration from the nest to sea may be vital to their survivorship. Although the cues involved in sea finding are complex, hatchlings rely primarily on vision for proper

orientation (Witherington and Martin, 2000; Lohmann et al., 1997). A combination of light and shapes is thought to be responsible. The extent to which one or the other drives the process may be a function of the relative strength of each stimulus.

Hatchlings have a tendency to orient toward the brightest direction. There are two mechanisms that would permit this type of orientation, the simplest of which is known as phototropotaxis (a turning and movement toward light). Hatchlings turn first in one direction and then in the other until the perceived light intensity are balanced between both eyes. When light balance is achieved, they will be facing the brightest direction. A more complex mechanism, telotaxis (fixation on and movement toward a target stimulus), allows instantaneous integration of light stimuli from many directions to establish brightest direction.

On natural undeveloped beaches the brightest direction is almost always away from elevated shapes (e.g., dune, vegetation, etc.) and their silhouettes and toward the broad open horizon of the sea. On developed beaches, the brightest direction is often away from the ocean and toward lighted structures. Hatchlings unable to find the ocean, or delayed in reaching it, are likely to incur high mortality from dehydration and predators. Hatchlings lured into lighted parking lots or toward streetlights are often crushed by passing vehicles (McFarlane, 1963; Philibosian, 1976; Peters and Verhoeven, 1994; Witherington and Martin, 2000).

When artificial lighting is strongly attractive, hatchlings move in a highly directed but incorrect path away from the ocean. This behavioral anomaly is termed **misorientation**. Less attractive lighting may prevent hatchlings from orienting in a constant direction either toward or away from the sea. Hatchlings crawling erratically are said to be **disorientated**. Throughout the remainder of this manual, **both types of misdirected crawling will be referred to as disorientation**, as that is the term most frequently used by sea turtle conservationists in describing events where hatchlings do not crawl directly to the ocean after leaving the nest.

How Hatchling Sea Turtles Perceive Light

To reduce the effects of artificial lighting on sea turtles, it is first essential to understand how sea turtles perceive light in their environment. First, and most importantly, strategies to resolve lighting problems must recognize that man's common notions of brightness and color do not apply, because sea turtles and humans perceive light quite differently.

Both the color (wavelength) and relative brightness of light sources are important in the sea-finding capabilities of hatchling sea turtles (Witherington and Martin, 2000; Lohmann et al., 1997). Green turtles are strongly attracted to light in the near ultraviolet to yellow region of the visible spectrum (360 to 600 nm) but are relatively indifferent to light in the yellow-orange to red region (630 to 700 nm; Figure 1). Loggerhead turtles are also strongly attracted to short wavelength light, but unlike green turtles, have an aversion to bright light in the green-yellow to yellow spectrum (560 to 600 nm); loggerheads are

only moderately attracted to longer wavelength light in the orange and red spectra. The relatively high sensitivity of turtles to short wavelengths is not surprising considering that they live in a medium, the ocean, that selectively filters out long wavelength colors.

The relative attractiveness of hatchlings to different colors is a function of brightness. Relatively low intensities of ultraviolet to green light (short wavelengths) are needed to elicit an orientation response in loggerhead hatchlings, whereas much higher intensities of long wavelength light would be required to elicit a similar response (Witherington and Martin, 2000). It is important to note that hatchlings can be attracted to even long wavelength red light at very high intensities.

Most light sources are composed of many wavelengths, each representing a different color. However, we are unable to distinguish among the spectral components; we see only a single color. The same is true for sea turtles. However, because of differences in spectral sensitivities, the color emitted by a particular light source may not appear the same to humans as to sea turtles. Similarly, two light sources appearing very similar in color to humans may appear dramatically different to sea turtles. This can have important implications for effective light management. For example, a source emitting monochromatic (single wavelength) yellow light is unattractive or only weakly attractive to hatchlings. Yet, another source, which also appears yellow to humans but contains both green and red spectral components, can be highly attractive to hatchlings because of the green wavelengths present. Consequently, we cannot rely solely on color when determining whether or not a light is likely to attract hatchlings.

In addition to their spectral sensitivity, hatchling sea turtles also are sensitive to the directional component of light (Witherington and Martin, 2000; Lohmann et al., 1997). As hatchlings assess the brightest direction, they integrate light through a broad, relatively flat cone of acceptance (Figure 2). For loggerhead turtles, the cone of acceptance is about 180° wide and only from about 10° to 30° above the ground. This implies that light reaching the hatchling (illuminance) from all sources combined is more important in influencing orientation than is the brightness of light emanating from a particular source (luminance). Furthermore, light near the horizon plays the greatest role in determining orientation direction. Thus, color, brightness, proximity to the beach, and broadcast characteristics combine to determine the relative attractiveness of a light source to a hatchling.

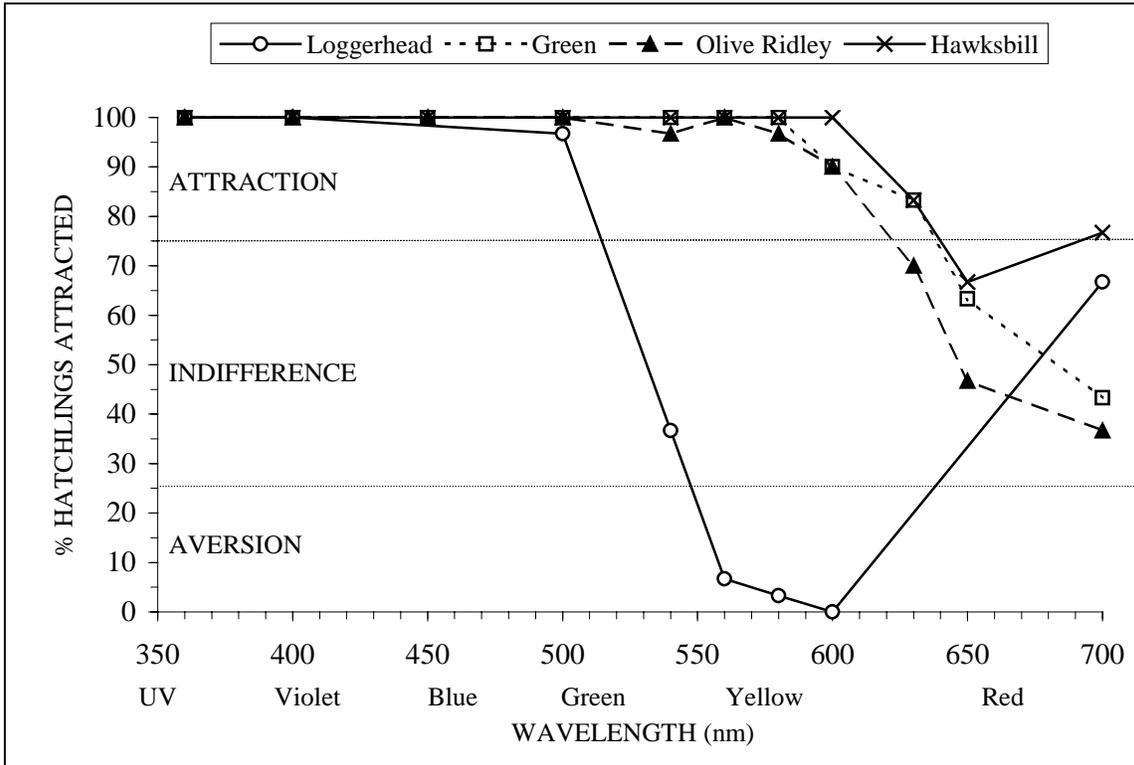


Figure 1. Orientation responses of four species of sea turtle hatchlings to colored light sources. Responses were measured as the proportion of hatchlings that chose an illuminated window over a similar but darkened window. Aversion indicates that hatchlings preferred the dark window to the lighted window. Indifference is the statistically random choice of windows according to a binomial probability test at $\alpha = 0.05$. Figure taken from Witherington, 1997, with permission.

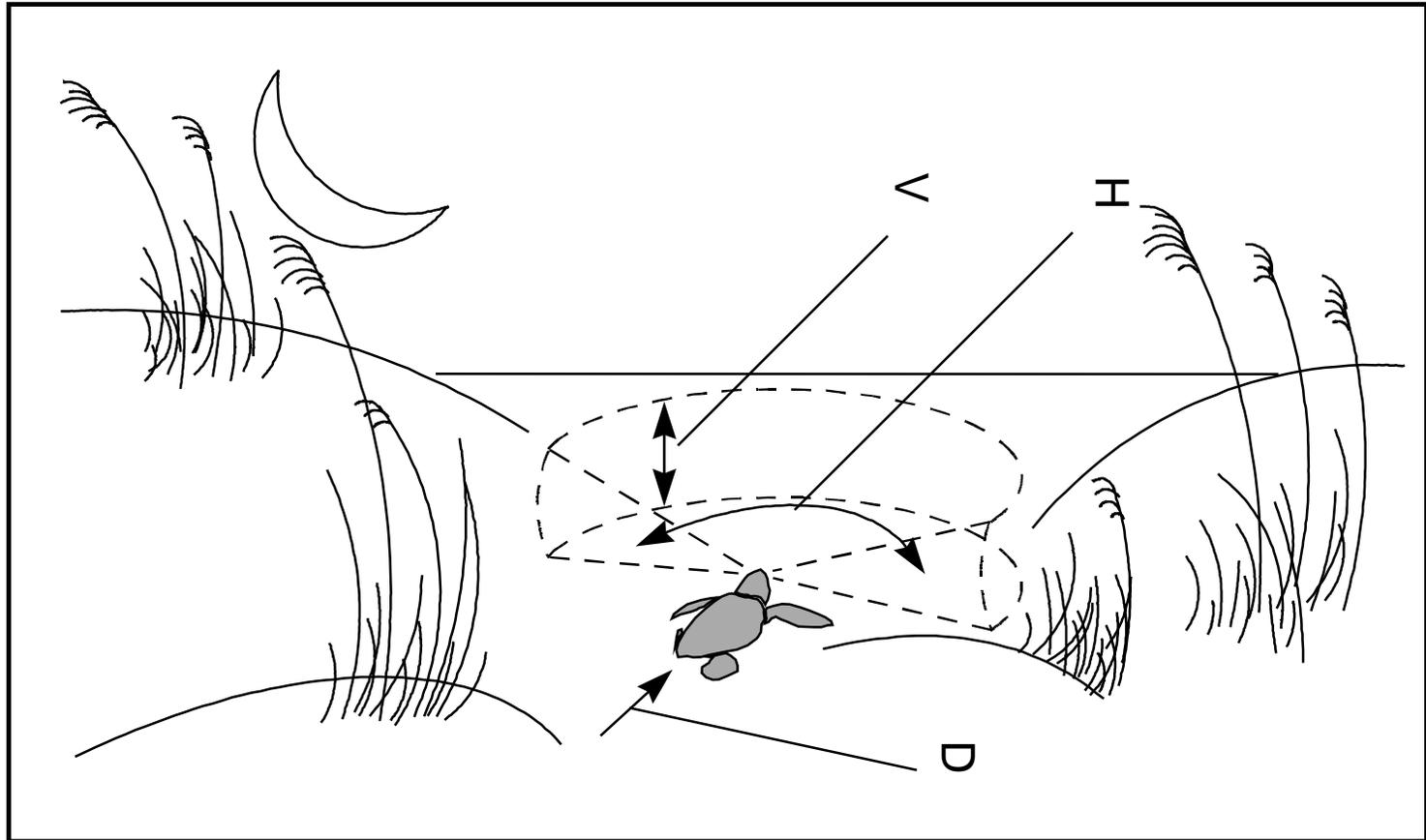


Figure 2. A hypothetical cone of acceptance that describes how a sea turtle hatchling measures brightest direction. The vertical component of the cone (V) is approximately $10-30^\circ$ from the horizon, and the horizontal component of the cone (H) is approximately 180° . Light sources within this cone of acceptance are thought to be integrated into an assessment of brightness for the direction D . Figure taken from Witherington, 1997, with permission.

Questions frequently arise as to why a light source near the beach has any more influence over a hatchling's orientation than does a full moon. Although celestial light sources are very bright, they are also very distant. As light travels from these sources to earth, it is scattered by the atmosphere and reflected off the ocean and features on land. As a result of these moderating influences, by the time celestial light reaches the beach, it is only moderately directed. From a hatchling's perspective, celestial light does not make one direction appreciably brighter than another does. On the other hand, artificial light sources, although not as bright as celestial sources, are relatively close to the beach. Light reaching the beach from these sources is highly directed. From a hatchling's perspective one direction (the one towards the artificial light source) is often much brighter than all others, and this typically will be the direction in which the hatchling will choose to orient.

Although a bright moon does not interfere with hatchling orientation, it may diminish the extent of disruption caused by nearby artificial lights. By illuminating broad areas of the beach, moonlight diminishes the directivity of nearby artificial light fields. Consequently, artificial lights typically are more disruptive to hatchling orientation on nights around a new moon than on nights around a full moon.

Based on the above information, it is apparent that most commercially available light meters would prove inadequate in determining whether or not a light source is likely to be disruptive to sea turtles. First, hatchlings show a preference for short wavelength light and respond to light (e.g., ultraviolet) that we cannot even see. Second, illuminance is "measured" by hatchlings through a broad flat cone, which is dissimilar to the acceptance cones utilized in most light meters. Third, light meters measure light from all sources, not just that emitted from detrimental artificial sources. Thus, when measuring the amount of light reaching the beach from a particular artificial light source, the value obtained may vary considerably from one night to another depending on sky conditions and the amount of ambient (celestial) light present. Finally, the low intensity of light needed to elicit orientation behavior for certain wavelengths may be below the detectable limits of many light meters.

For these reasons, the best available illuminance meters are the hatchlings themselves. If hatchlings emerging from a nest are disoriented, there is typically a disruptive artificial light source nearby. However, rather than waiting for a disorientation event to occur, we should adopt a proactive posture and attempt to identify and remedy potential problem lights before hatchlings are negatively impacted. Later chapters of this manual present guidelines for determining if a light is likely to cause a problem and discuss alternative lighting options for resolving identified problems.

For a more thorough review and assessment of lighting impacts on sea turtles and other nocturnal animals refer to Witherington and Martin (2000), Lohmann et al. (1997), and Witherington (1997). (For complete references to these reviews, see the Literature Cited section beginning on Page 63 of this manual.)

CHAPTER 3

SUMMARY OF ISSUES RELATED TO COASTAL ROADWAY LIGHTING

As in most conflict-resolution cases, a variety of issues other than sea turtles must be considered when proposing changes to street lighting. “Satisfactory” resolution of street lighting problems implies that all relevant public interests have been accommodated to the greatest extent practicable.

Rarely is a streetlight whimsically placed along a coastal roadway. It has a purpose, based on public need, and must be permitted, positioned and operated in a manner that fulfills that purpose. Clearly, the simplest and most effective way of preventing lighting impacts is to turn off the offending light(s). However, public safety must also be considered. Costs are also an issue. It is unlikely that an exorbitantly priced lighting alternative will be popular with local officials or the constituents they serve. To be sure, there are compelling reasons for correcting problem lights and potential consequences for failing to do so. Nevertheless, proposed solutions must be sensitive to the purpose of, and public need for, street lighting. The criteria used by the TWG in framing acceptable lighting solutions are presented below.

Sea Turtles

The impetus for a Coastal Roadway Lighting Manual was an accumulating record of impacts to hatchling sea turtles from streetlights in Florida. In Chapter 2 (Summary of Effects of Coastal Lighting on Sea Turtles), we discussed why these impacts occur. Reasons for addressing the impacts are presented here.

Importance of Florida’s Nesting Beaches

The vast majority of nesting by sea turtles in the continental United States occurs in Florida. Three species regularly nest on Florida’s sandy shores: the loggerhead turtle (*Caretta caretta*), the green turtle (*Chelonia mydas*), and the leatherback turtle (*Dermochelys coriacea*). Two others, the hawksbill (*Eretmochelys imbricata*) and Kemp’s ridley (*Lepidochelys kempii*), have also been reported to nest here, although they do so infrequently.

Over 97 percent of nesting in Florida is by the loggerhead turtle (Meylan et al., 1995). The nesting population of Florida loggerheads is the second largest in the world and accounts for about a third of all nesting by this species worldwide (NMFS and USFWS, 1991a). Florida’s nesting green turtle population is one of the largest remaining in the Caribbean Sea and Western Atlantic (Meylan et al., 1995). No other state in the continental United States supports regular nesting by the leatherback. Thus, Florida’s beaches are of national, regional, and in some cases global, importance to the survival of sea turtles.

Regulations Protecting Sea Turtles

All species of sea turtles occurring in Florida are protected by the U.S. Endangered Species Act (ESA) of 1973 and Florida Statutes (Chapter 370.12 FAC). The loggerhead turtle is listed federally as a threatened species, while all other species in Florida are listed as endangered.

Section 9 of the ESA prohibits the “**take**” of any threatened or endangered species of plant or animal. Take, as defined by the ESA, means “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” Obvious examples of take are those activities that cause direct injury or death to a listed species or remove it from its habitat. However, more subtle impacts, such as harm and harass, also fall under the definition.

Harm includes acts that significantly modify or degrade habitat to such an extent as to kill or injure wildlife by impairing essential behavioral patterns. Harass is “an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.” Thus, by degrading nesting habitat, interfering with essential reproductive behavior, and contributing to the death of hatchlings, problem street lighting constitutes take under the ESA. Similar definitions are contained in Florida’s Marine Turtle Protection Act (370.12 Florida Statutes).

Recovery plans for U.S. sea turtle populations place considerable emphasis on preserving, and where possible improving, the quality of Florida’s beaches as nesting habitat (NMFS and USFWS, 1991a; NMFS and USFWS, 1991b; NMFS and USFWS, 1992). Management of artificial light near the beach is critical to this effort.

Two agencies are responsible for the conservation and recovery of sea turtle populations on their nesting beaches in Florida, USFWS and FWC. USFWS (the Service) is responsible for enforcing the provisions of the ESA. When take of hatchlings occurs, this agency has the authority to pursue civil penalties against the owners of the responsible light and/or refer the case to the Department of Justice to pursue criminal penalties. Typically enforcement action is initiated only after the offending party has been notified about the problem and fails to take appropriate corrective action to prevent future occurrences (i.e., additional take).

The USFWS feels that if recommendations contained in this manual are followed, take of sea turtles is unlikely to occur. Nevertheless, it cannot ignore additional take that may occur if a selected light management option proves ineffective. However, as long as the party responsible for resolving the problem puts forth a good faith effort and works cooperatively with the Service to achieve an effective solution, it will not recommend prosecution under the ESA (see statement from USFWS in Appendix C). Although the lighting custodian (typically a municipal or private utility) plays an important role in helping

to select and implement an appropriate lighting modification, the party ultimately responsible to the USFWS for resolving the problem is the person or entity paying for the lighting service (i.e. utility customer/rate payer). The rate payer must, therefore, determine which of numerous corrective actions, including non-use, is acceptable for their specific street lighting situation and direct the lighting custodian accordingly.

FWC is responsible for administering Florida's Marine Turtle Protection Act and for assisting with national sea turtle recovery efforts through a cooperative agreement with USFWS. One of the major roles of FWC is the permitting of qualified individuals to conduct hands-on sea turtle conservation activities on Florida's nesting beaches. These activities include daily monitoring of nesting activities, nest protection, and documentation of factors adversely affecting the reproductive cycle.

Each morning throughout the nesting season, permit holders and their designees survey beaches around the state for signs of nesting. Frequently nest sites are marked and monitored for signs of hatching. Whenever hatchling tracks emanating from a nest show obvious signs of disorientation, a standard reporting form is completed and sent to FWC. The form identifies the species of turtle involved, the geographic location of the nest, the approximate number of hatchlings disoriented, the general direction of their travel, and potential light sources that may have been responsible. If a lighting ordinance is in effect, either the permit holder or FDEP typically furnishes a copy of the report to the local code enforcement department for action. If no lighting ordinance is in effect, the property owner is usually notified directly and advised of the problem.

Most coastal communities adjacent to sea turtle nesting beaches in Florida have adopted beachfront lighting regulations. When a local government learns of a problem light, they typically notify the responsible party and advise them that the light is in violation of code. Ideally, they are able to provide proper guidance in resolving the problem. At all levels of government, voluntary compliance with local ordinances and a cooperative spirit in resolving identified problems are preferable to heavy-handed enforcement. However, if this approach fails, code enforcement action may be necessary. Records of persistent lighting problems are furnished to USFWS by FWC for federal prosecution under the ESA.

Basic Approach to Roadway Light Management

Based on behavioral responses of sea turtles to artificial lighting, it was the consensus of the TWG that effective streetlight management requires a three-tiered, step-down approach:

- 1) **Keep Lights Off the Beach**

The first and most important tier is to design or modify lights in such a manner that the light is confined to the roadway and is prevented from straying onto the beach. As discussed in later chapters of this manual, this can be accomplished by changing the light broadcast properties of a fixture and/or

realigning, repositioning, shielding, and/or screening light sources from beach view.

2) Reduce Luminance/Brightness

If the first set of modifications does not completely resolve a problem, additional measures may be required. The second tier involves a reduction in the total luminance (combination of lamp wattage and number of fixtures) of roadway lights to the minimum required for pedestrian and motorist safety. This may require selectively turning off certain lights, decreasing the total number of fixtures, and/or reducing the wattage of lights closest to the beach.

3) Change Spectral Qualities

For essential lights very close to the beach, yet an additional set of modifications may be appropriate. The third and final tier involves utilization or modification of lights such that the quality (color) of light emitted is less attractive to hatchlings than light from traditional sources. Although at present there is no truly “turtle-friendly” luminaire, some lights are less disruptive than others. However, even these color-sensitive light sources must be properly managed to prevent harm to sea turtles and, thus, **should only be utilized in combination with options identified in the first two tiers.**

At a minimum, light management should be in place throughout the sea turtle nesting season (see below). However, it is recommended that permanent solutions be developed and light management practices be adhered to year round. This negates the need for seasonal adjustments.

The Nesting Season

Sea turtles typically begin nesting on Florida’s beaches in spring and continue through late summer. There is some offset in the timing of reproductive activity among species, with leatherback turtles being the first to emerge onto area beaches and green turtles being the last. Peak nesting occurs in June and July.

It typically takes about two months for incubating eggs to hatch. Thus, eggs laid in mid-August would not hatch until mid-October. The inclusive period during which turtles are nesting and hatchlings are emerging from nests is termed the nesting season. In southeast Florida, where the majority of nesting occurs (Table 1), FWC considers the period from March 1 through October 31 to be the official nesting season. This area includes Brevard, Indian River, St. Lucie, Martin, Palm Beach and Broward Counties. Throughout the remainder of Florida, the official nesting season runs from May 1 through October 31 each year.

Table 1
Contribution by Coastal County to Sea Turtle Nesting in Florida

| Coastal County | Percentage of Statewide Sea Turtle Nesting ¹ |
|----------------|---|
| Bay | 0.14 |
| Brevard | 39.68 |
| Broward | 3.32 |
| Charlotte | 1.34 |
| Citrus | None Documented |
| Collier | 1.51 |
| Dixie | None Documented |
| Duval | 0.10 |
| Escambia | 0.08 |
| Flagler | 0.33 |
| Franklin | 0.54 |
| Gulf | 0.48 |
| Hernando | None Documented |
| Hillsborough | 0.06 |
| Indian River | 5.17 |
| Jefferson | None Documented |
| Lee | 0.95 |
| Levy | None Documented |
| Manatee | 0.44 |
| Martin | 11.94 |
| Miami-Dade | 0.60 |
| Monroe | 0.48 |
| Nassau | 0.14 |
| Okaloosa | 0.05 |
| Palm Beach | 17.79 |
| Pasco | None Documented |
| Pinellas | 0.26 |
| Santa Rosa | 0.02 |
| Sarasota | 4.24 |
| St. Johns | 0.33 |
| St. Lucie | 7.44 |
| Taylor | None Documented |
| Volusia | 2.49 |
| Wakulla | None Documented |
| Walton | 0.08 |

¹ Average annual nesting for all species combined, 1996-2000(from FWC, FMRI 2002)

Roadway Lighting

Regulatory Authority

Coastal roadways fall under several different jurisdictions: federal, state, county, or incorporated municipality. Most major arterial highways running along the coast, such as A1A on Florida's east coast, fall under the purview of the Florida Department of Transportation (FDOT). Although the U.S. Department of Transportation (USDOT) funds federal roads, they are typically built, maintained, and regulated by FDOT. FDOT establishes design, maintenance, and safety standards for lighting on all public roads, even though the maintenance of the lighting systems may be delegated to the counties and municipalities within which the roads are located.

If lighting was not installed on state or federal roads during project construction, local governments may petition FDOT for use of the right-of-way for that purpose. Chapter 337, Florida Statutes, and Chapter 14-46, Florida Administrative Code (FAC), establish that all lighting on state roadways be authorized by FDOT through written permit. FDOT issues permits for the construction, alteration, operation, relocation and maintenance of utilities upon state road rights-of-way in conformity with the Department's Utility Accommodation Manual. The FDOT Plans Preparation Manual establishes minimum standards for the design of lighting systems.

Copies of the above-referenced FDOT documents can be obtained through: FDOT Maps and Publications Sales, 605 Suwannee Street, Mail Station 12, Tallahassee, Florida 32399-0450 or from FDOT's web site at <http://www11.myflorida.com/mapsandpublications/>

Sub-section 14-64.0011 of Chapter 14-64, FAC (Illumination of the State Highway System) indicates that no lighting system can be installed on any part of the state highway system or its associated right-of-way until "there has been executed a valid contract with the responsible local authority for that authority's maintenance, operation, and assumption of legal liability for that lighting system in those cases where the Department establishes it has no responsibility to maintain and operate the lighting system." Thus, when FDOT permits the placement of lights on state road rights-of-way, the local authority assumes liability for that lighting system.

Florida Roadway Lighting Standards

FDOT requires that lighting for systems it permits must meet minimum standards for highway safety. These include:

1. **Mounting Height** - Mounting height is the vertical distance between the roadway surface and the center of the light source. This distance is established to provide adequate clearance for cars and trucks and to minimize glare off the

roadway surface. Mounting heights vary depending on the photometric properties of the fixture and the wattage of the lamp being used.

2. Pole setback - The light pole must be a minimum distance from the edge of the travel lane to ensure adequate traffic safety. This distance is established in accordance with the Plans Preparation Manual. Setbacks vary with location and setting.
3. Wind loading - In Florida tropical storms are frequent. Consequently, the structural supports of light fixtures (e.g., poles and bracket arms) must be strong enough to withstand high winds. Wind loading criteria is determined by the National Electric Safety Code and varies between entities and among geographic regions of the state (Figure 3).
4. Illuminance - Good visibility is one of the fundamental requirements of safe driving. Street lighting enables motorists to more clearly see other vehicular traffic, pedestrians, obstructions, and signs on or adjacent to the roadway at night. It also improves nighttime visibility for other roadway users, including cyclists and pedestrians. Minimum levels of illuminance, the amount of light striking the roadway surface, are established by the FDOT.
5. Light uniformity ratio - In addition to the amount of light reaching the roadway surface, its distribution should be uniform to provide optimum driver comfort and safety. Uniform light distribution eliminates the bright-dark picket fence phenomenon (caused by widely spaced lights) that can create dangerous driving conditions.

Altering Roadway Lighting Systems

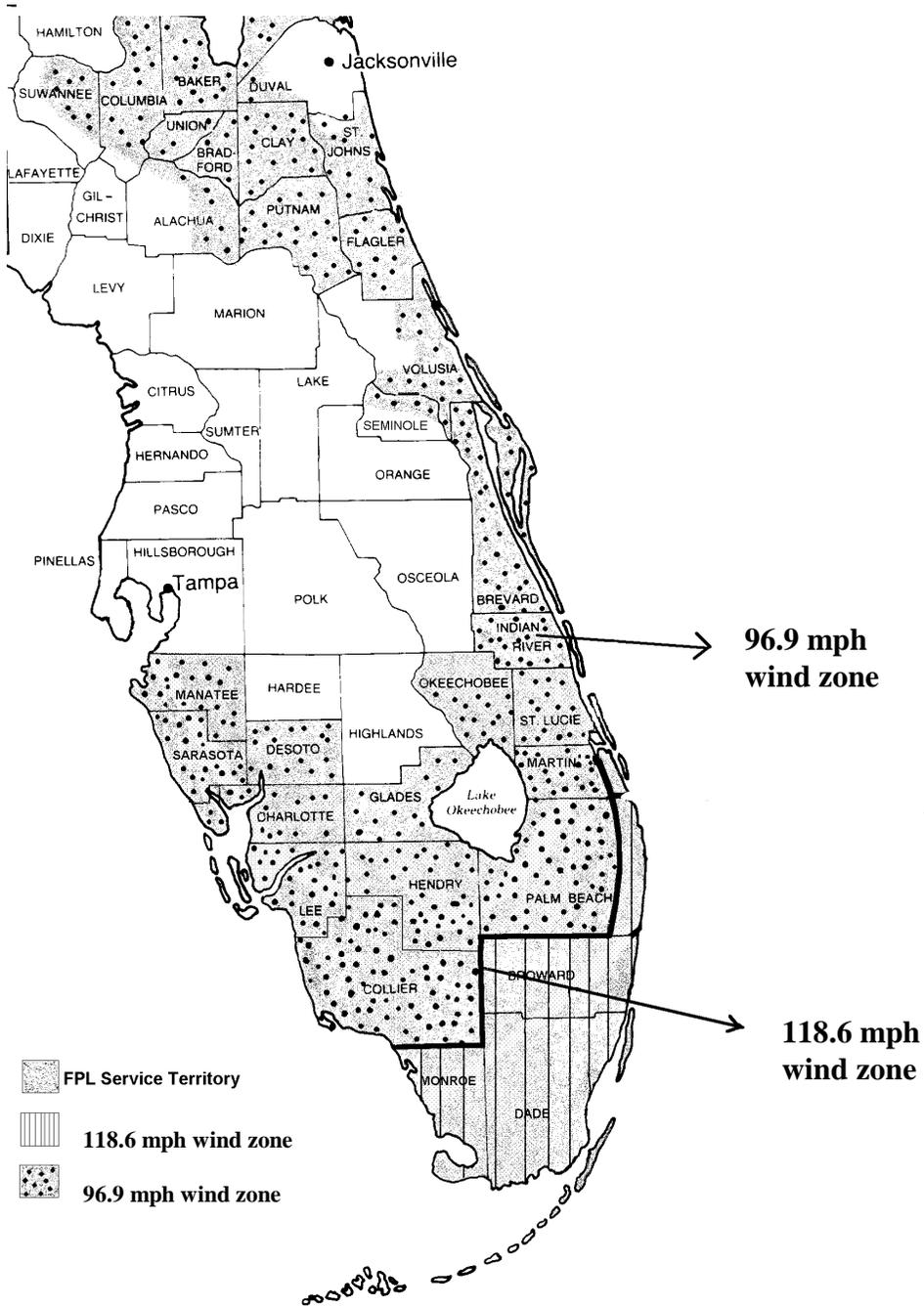
When a street lighting problem is identified, several parties have an interest in determining how the problem is resolved: the user, the custodian, and the permitting authority.

User - The user is the entity that is paying for the use of the lighting system. This is the utility customer or rate payer. Ultimately, it is the user's responsibility to evaluate and balance competing interests when deciding how best to resolve a lighting problem.

Custodian - The lighting custodian, usually an electric utility, installs and maintains streetlights and provides electricity to the system. The custodian must work with the user to develop solutions appropriate to the specific lighting problem.

Permitting Authority - The permitting authority is the agency that authorized right-of-way usage and/or roadway lighting installation.

Figure 3
Wind velocity zones for Florida, as determined by the NESC for electric utilities.



In the simplest cases, the user, custodian, and permitting authority are the same party. Typically, however, two or more parties are involved in streetlight management efforts.

When a street lighting problem is identified, the user, in consultation with the lighting custodian, must first consider under whose authority the light is operated and maintained before undertaking any modifications. As noted above, FDOT has oversight of state and federal roadway lighting systems as well as local roadway lighting systems funded by the state. For other systems, county or city authorities must be notified.

If a state permit was issued for right-of-way usage, the permittee (usually a local government) must contact the local FDOT maintenance office to discuss the proposed changes. Any substantive changes will be forwarded to the appropriate FDOT regional office for review and/or approval.

Deviations from established lighting standards might occur when the amount and/or distribution of light on the roadway surface is altered to protect sea turtles. Thus, variances and waivers may be needed for proposed lighting modifications, depending on the affect the modification is expected to have on highway safety. If safe operation of the highway facility is likely to be impaired by a deviation from design standards, an official variance is required under Section 120.542, Florida Statutes, and rules adopted pursuant thereto. On a case-by-case basis, FDOT may modify permits to allow flexibility in dealing with roadway lighting and protected species conflicts, provided the permittee expressly assumes liability for changes to the lighting system. Additionally, signage warning drivers of poor highway conditions may be appropriate if substantial deviations from highway safety standards are likely to result from lighting modifications.

At present, roadway lighting standards are based almost exclusively on traffic safety. It has been estimated that between 35-50% of atmospheric light pollution is caused by roadway lighting (Finch, 1978). Yet, despite our increasing understanding of the effects of light pollution on sea turtles and other wildlife, little consideration is given to this phenomenon in the design or permitting of lighting systems. Clearly, there is a need for special lighting standards along coastal roadways adjacent to sea turtle nesting beaches. The FDOT has begun the process to establish Alternative Lighting Standards in Sea Turtle Lighting Zones along FDOT coastal roadways in Florida.

FDOT roads adjacent to sea turtle nesting beaches were classified into four categories as a result of a recent FDOT-funded Florida Atlantic University study. FDOT is considering allowing Alternative Lighting Standards in these zones, which they are currently in the process of developing. The alternative standards would utilize the light management techniques contained in the Coastal Roadway Lighting Manual and the Witherington and Martin (2000) lighting manual. Any changes to roadway lighting standards and/or the permitting process resulting from this effort would be incorporated into future editions of the Coastal Roadway Lighting Manual.

Public Safety

There are a variety of social and economic benefits attributable to roadway lighting, including but not limited to:

- 1) Facilitation of traffic flow,
- 2) Reduction of nighttime accidents,
- 3) Aid to police protection,
- 4) Promotion of roadside businesses, and
- 5) Safety for pedestrians and bicyclists.

With respect to light management, perhaps one of the most fervently debated issues is that of crime and public safety. There is a strong public perception that efforts to reduce light pollution will increase crime. This is based largely on the premise that light management equates to lights out. As outlined earlier in this manual, the intent of streetlight management is to:

1. Confine light to the area of its intended use,
2. Reduce the amount of light emitted to the minimum required to effectively achieve its intended purpose, and/or
3. Use light sources that minimize the potential for hatchling disorientation.

Although streetlight management efforts may not eliminate light on coastal roadways, they may alter the amount, color, and/or distribution of that light. Reduced levels of illumination and changes in light color are often viewed as less safe. To obtain feedback on any impact these modifications might be expected to have on law enforcement activities, a questionnaire was furnished to the traffic safety departments of the 12 counties and cities represented on the Coastal Roadway Lighting Manual Steering Committee. Nine of the questionnaires were returned. Although the sample is small, the results are informative.

The preference of law enforcement personnel was unambiguous. They would like to have brightly illuminated roadways, with light that is uniformly distributed and does not distort colors. However, when asked how inferior lighting conditions would affect job performance, the responses were mixed. For example, respondents felt that it was important to be able to distinguish colors. (Low pressure sodium vapor lamps, which emit monochromatic yellow light, distort colors.) But, when asked if poor color rendition would affect job performance or place officers at risk, the importance factor was neutral (5 on a scale of 1 to 10, ranging from not important to extremely important). Similarly, respondents felt that uniform light distribution was very important in deterring crime and

improving traffic safety. However, they felt that intermittent light would only moderately affect their job performance.

The above results are not a measure of the effect of light management on public safety. They merely reflect the perception that law enforcement personnel have on the effect(s) of different lighting conditions on public safety and job performance. It is not surprising that when asked to rank various combinations of brightness, distribution and color reliability, respondents ranked bright, uniformly distributed light with good color rendition as the most desirable option and no light as the least desirable.

Typically, the issue of crime arises as light management efforts are proposed. In response to questions from a county seeking input on the effects of lighting ordinances on crime, an assistant state attorney cited correspondence from several municipalities that had enacted such ordinances. In a letter to Dennis K. Bayer, Assistant State Attorney, dated July 31, 1989, the Chief of Police of the City of New Smyrna Beach (Volusia County, Florida) indicated that “criminal activity in relationship to the lighting ordinance on the beach proper was negligible at best.” Following ordinance implementation, there were no increases in burglary, larcenies or vandalism other than that which would be considered normal.

As in the case of New Smyrna Beach, much of the available information on light management and crime is anecdotal. There is little hard data to allow statistical comparisons of crime before and after ordinance enactment. Nevertheless, considering that most of our current information on the effects of light management comes from those tasked with combating crime, there is no rational basis for concluding that light management programs will lead to increased crime. This does not imply that crime and public safety are not important local issues. They must certainly be considered in the selection of lighting alternatives for areas where streetlights cause problems for sea turtles. The important point, though, is that an altered lighting environment may be perceived as being more detrimental to public safety than it actually is.

Regulation of Utilities

The Florida Public Service Commission (PSC) is the board that regulates utility rates and levels of service in Florida. Utilities that install and maintain roadway lights file tariffs which must be approved by the PSC. The tariffs prescribe the types of lights that can be offered and the rates charged for each.

For example, the selection and use of streetlights by FPL, the state’s largest electric provider, is governed by its Rate Schedule SL-1, which is a part of FPL’s electric tariff on file with the PSC. Under Rate Schedule SL-1, only high pressure sodium vapor (HPS) luminaries are allowed for new FPL-owned streetlight installations. Low-pressure sodium vapor lighting (LPS) is not offered as an option for any street lighting systems, because it has not been approved by the PSC. No changes to FPL’s rate schedule may be made without approval from the PSC, after appropriate administrative proceedings.

Without such approval, the use or installation by FPL of any luminaire type not included in the rate schedule is prohibited. Similar restrictions apply to other utilities.

Options Offered by Electric Utilities

Streetlights

Utilities generally provide their customers with the following street lighting options:

- Utility-owned streetlights and full maintenance service.
- Relamping of customer-owned streetlights.
- Energy service to customer-owned streetlights.

If a power provider installs and maintains the lights of its customer (user), utility-specific policies may dictate which light management options are available. For example, at present FPL can perform the following modifications to streetlights that are disruptive to sea turtles: (NOTE: Any modification or alteration of light levels on a roadway must be approved by the appropriate agency, i.e. DOT, county, etc.)

- 1) Seasonally turn the lights off,
- 2) Relocate or redirect the light fixture,
- 3) Change a drop globe fixture to a cutoff style fixture,
- 4) Remove the fixture,
- 5) Lower mounting height,
- 6) Reduce wattage,
- 7) Selectively install amber-colored filtering lenses (on cutoff fixtures of 70-watts or less and only in addition to other modifications), and
- 8) Install a light shield. (**NOTE:** At this time, FPL cannot apply light shields to FPL-owned streetlights, because none of the shields currently available meet the wind loading criteria for FPL's service territory, as dictated by the National Electric Safety Code. FPL is currently working with various manufacturers to develop new light shields that can be used within its service territory).

Other Outdoor Lighting

Outdoor lighting is also offered by FPL. It is not intended for roadway lighting but rather for year-round security lighting of private property. Normally the fixture used for this type of installation is directional or open-bottom. They are installed on existing light poles. To avoid disorientation of sea turtles, the same light management techniques as noted above for streetlights should also be applied to outdoor lights that are visible from the beach.

Options Offered by Private Suppliers

Utility-owned structures may be removed and replaced with facilities purchased from a private contractor. Light management principles and practices should be similarly applied in these situations. (NOTE: Any modification or alteration of light levels on a roadway must be approved by the appropriate agency, i.e. DOT, county, etc.)

Low-Pressure Sodium Vapor (LPS) Lighting

LPS is an alternative to high pressure sodium vapor (HPS), which is the most widely used type of lamp for street lighting. Because the monochromatic properties of LPS have been shown to be minimally disruptive to sea turtles, conservationists often advocate its use. However, most utilities do not offer LPS, citing the following disadvantages:

- 1) It distorts color,
- 2) The large fixtures required for LPS typically do not meet wind loading criteria, and the fixtures deteriorate relatively quickly in the salt-air environment of coastal roadways (resulting in higher maintenance),
- 3) Both initial and operational costs for LPS lights are substantially higher than for HPS lights,
- 4) The distribution of lighting is more difficult to control (more lights are needed for uniform distribution),
- 5) Replacement cycles for LPS lights are more frequent than for HPS lights (i.e. shorter operational life), and
- 6) LPS have environmental concerns that require special disposal procedures.

Others (e.g., see Witherington and Martin, 2000) contend that although initial costs for LPS lights are higher than for HPS lights, electricity costs are generally lower, because LPS lamps are more efficient (more lumens per watt). In practice, operational costs may vary, depending on how the lights are used in a particular utility's lighting system. Regardless of overall costs, there are some drawbacks to LPS usage. Principal

among those are the large fixtures required to house the lamps. These fixtures are susceptible to damage during high winds, require more maintenance, and typically have more omni-directional broadcast properties than conventional light fixtures (i.e. more difficult to control light distribution).

Although LPS lights distort colors, the effect of this phenomenon on crime and public safety may be more a factor of public perception than of reality. In Delray Beach, Florida, where LPS lights were used in an experimental demonstration project, local law enforcement personnel reported that color distortion did not noticeably affect the performance of their duties. Prior to installing LPS lights, local law enforcement should be contacted for input.

Experimental Technologies

Filters

Research: During preparation of the Coastal Roadway Lighting Manual, several new technologies were developed and/or reviewed as possible additions to the tools available to achieve effective light management. One such technology involves light filtering lenses.

Amber colored lenses filter out much of the short-wavelength light emitted by HPS street lamps. Unlike other types of long-pass filters (e.g., dichroic filters), the angle at which the light strikes the lens has relatively little effect on its filtering properties. Because amber lenses do not produce monochromatic light, there is much less color distortion than with LPS light. Filtering lenses are appealing because they are relatively inexpensive, are easy to install and maintain, and can be applied to existing HPS fixtures.

Research, therefore, focused on determining how effective these lenses could be in mitigating turtle disorientation from artificial light.

Three types of amber lenses were developed and evaluated:

- Flat and molded acrylic.

Two types of acrylic products were assessed. Atohaas 2422™ is a sheet product, about 1/8-inch thick, used to fashion flat lenses that can be applied to Cobrahead cutoff fixtures with low wattage lamps (e.g., GELS 70W M250). Atohaas 938™ is a molding pellet product that can be formed into bowl lenses that can be applied to drop globe fixtures with higher wattage lamps (e.g., GELS 150W M250).

- Lexan® polycarbonate sheeting.

Lexan® (#4158 sheet product) is a polycarbonate material that can be formed into either a flat lens for cutoff fixtures or a molded drop globe for standard fixtures.

- Stained glass.

Glass treated with an inorganic stain (e.g., SC-V55 available through GELS) may also be used in either flat or prismatic applications. Glass is advantageous for relatively high wattage applications, because the acrylic and polycarbonate lenses tend to warp or discolor with increasing heat.

Results: In controlled field experiments (see Chapter 4, Page 29, Hatchling Arena Assays) conducted during the summer of 1998, hatchlings were introduced to light filtered by flat acrylic (Atohaas 2422™), flat stained glass, and molded acrylic (Atohaas 938™) amber lenses. Best hatchling orientation occurred with the Atohaas 2422™ flat acrylic lens in a cutoff fixture with a 70-watt lamp. Less favorable results were obtained with the flat stained glass and acrylic drop globe lenses. All of the lenses tested did result in some reduction in orientation response relative to control groups with streetlights turned off. The researchers who evaluated test results felt that orientation responses were superior to those that would have occurred if the street lighting had not been filtered at all. However, more disorientation occurred than if the lights were turned off, meaning the filters were only partially effective.

The lenses were tested in controlled laboratory and field experiments between 1998 and 2001 (see Cowan and Salmon 1998, Salmon 1999a and 1999b, Nelson et al, 2001). The field studies indicated that adult turtles were not attracted to filtered light and nest site selection was not significantly affected by filtered light. In the laboratory, hatchlings were less attracted to filtered light than unfiltered light of comparable brightness. However, field studies, particularly those utilizing green sea turtles, indicated that the presence of filtered light still resulted in some degree of hatchling disorientation. Consequently, these filters should never be used in lieu of other light management options, but rather in addition to other modifications.

Conclusions: Of these four filters, only the Atohaas 2422™ demonstrated any lessening effect on hatchling disorientation. **Due to the mixed results, amber lenses should only be used in combination with other light management options and should never be considered an adequate solution when used alone.** FWC will not recommend for approval any lighting plan containing filters that does not also propose to implement all other available and appropriate light management options.

Any advances in lens performance will be included in future editions of this manual.

FDOT's Embedded Roadway Lighting Study

In order to further study alternative roadway lighting systems, FDOT funded a demonstration project in 2001 that utilized embedded roadway lighting products. Consultants contracted by FDOT researched available lighting products, designed and installed a system, and are currently maintaining it. The system was installed at State Road A1A and Spanish River Boulevard in Boca Raton, Florida. This section of roadway was selected because there was a history of hatchling disorientations on adjacent beaches, there was a vegetative screen between the road and the beach, the roadway is not heavily traveled in the summer months, and the community was particularly sensitive to the needs of sea turtles. Florida Atlantic University (FAU) Researchers conducted arena assays in order to determine how sea turtle hatchlings responded to this type of roadway lighting. FAU found that hatchlings responded to the embedded light system in the same manner as when the streetlights are turned off. The University of Florida Department of Civil Engineering is conducting a study to determine motorist/pedestrian response to this type of lighting system. The results of the study will be disseminated during the summer of 2002. The embedded roadway lighting system will again be energized during the 2002 nesting season.

Economics

Light management comes with cost. Depending on the management option(s) selected, the cost may be nominal (in the case of turning lights off) or substantial (when major system-wide changes are implemented). However, as indicated by Witherington and Martin (2000) initial implementation costs may be at least partially offset by electrical savings resulting from reduced wattage or more efficient types of lamps.

The utility customer (streetlight user) is ultimately responsible for shouldering the costs of light management efforts. In estimating potential costs associated with a particular lighting modification, the customer should consider the following:

- 1) Installation of new, or modification of existing, equipment and accessories,
- 2) Maintenance,
- 3) Product longevity (i.e. replacement frequency), and
- 4) Energy consumption (i.e. operational expense of the light or system).

In assessing these costs, the customer should also consider the consequences of potential regulatory agency action under the ESA, Florida Statutes, and/or local ordinances for failure to take responsible action to resolve identified lighting problems.

Relative costs for several lighting management options are provided in Appendix D.

Grant and other funding sources are listed in Appendix E.

CHAPTER 4

GUIDELINES FOR IDENTIFYING PROBLEM LIGHTS

Usually, neither the user nor the lighting custodian is aware that a streetlight is causing harm to sea turtles until the problem is brought to their attention. There are three basic methods whereby problematic lights can be identified. One is reactive and the other two are proactive.

Disorientation Reports

The first indication of a problem is usually a report from FWC-permitted monitoring personnel attributing a hatchling disorientation event to a nearby light. The individuals reporting the event are typically familiar with the local nighttime lighting environment and are often able to identify the responsible light based on the path taken by hatchlings leaving the nest. In cases where numerous lights are present in the area of the disorientation, it may not be possible to assign responsibility to a specific light. In those cases, all potentially disruptive lights observed in the general area are reported. Even if a light is not solely responsible for a disorientation event, it may have contributed to the problem and should be carefully evaluated.

Upon receipt of a disorientation report, FWC and/or the local code enforcement department will notify the light user (customer/rate payer) and require that appropriate lighting modifications be made. Prior to undertaking any modifications, the user and/or lighting custodian should obtain a copy of the disorientation report and visit the site at night to evaluate the spatial extent and severity of the problem. This will facilitate selection of an effective lighting alternative (see Chapter 7, Selecting the Appropriate Alternative).

Nighttime Lighting Evaluations

Sometimes, lights may have a relatively high potential for causing problems for sea turtles but go unreported, because either no nests are laid near the light source or a disorientation event goes undetected. For this reason more proactive lighting assessments are recommended.

The most practical and conservative approach to light management is to perform visual nighttime evaluations of streetlights. Lights of primary concern are those within direct line of sight of the beach, because these lights have the potential for broadcasting light directly onto the beach. Lights that directly illuminate the beach will typically cause problems for sea turtles. Indirect illumination of the beach by reflected light may also be a problem. Additionally, all light contributes to cumulative skyglow. Skyglow, particularly in urban areas, can create problems for sea turtles, especially on cloudy nights.

The evaluation should be conducted on or near the date of the new moon (i.e. dark moonless night). This is the period when problems will be most evident. View each light from numerous positions on the beach, both near the waterline and near the dune. During the evaluation, be sure to walk a reasonable distance in both directions away from the light source. Often a light may be blocked from beach view from a position due seaward of the light because of buildings or vegetation. However, it may become very conspicuous when viewed from positions farther up or down the beach.

For each light fixture visible from the beach, note the following:

1. *Can the source of light (i.e. the bulb or lamp) be seen from the beach?*

Because sea turtles perceive light differently than humans, it is inappropriate to try to determine if a light will cause a problem based on its brightness or broadcast properties. As indicated by Witherington and Martin (2000), **an artificial light source is likely to cause problems for sea turtles if the source of light can be seen by an observer standing anywhere on the nesting beach.** This basic rule of thumb will allow light managers to easily identify potentially problematic light sources.

2. *Are there reflective surfaces on or near the fixture that broadcast light toward the beach?*

Depending on brightness of the light source and the distance of the reflective surface from the beach, indirect lighting can be just as disruptive to sea turtles as direct lighting. A good method for determining if light is reaching the beach is to stand on the beach facing the ocean and hold a piece of white, rigid material (e.g., poster board, clip board, etc.) at arm's length away from the light source. This positions the observer between the light source and the material. From a standing position, slowly move the material from side to side. If you cast a shadow on the material, light is reaching the beach.

3. *How extensive is the illumination? Can you see the light from only one small area of the beach, or is the source visible from most locations?*

The more extensive the illumination, the greater the potential for problems. Light visible from a crouching position on the beach (simulating a turtle's perspective) is likely to be more disruptive than light only visible from a standing position. Although both situations warrant remediation, the former should be given a higher priority if resources available for lighting modifications are limited.

All of the information obtained during nighttime lighting evaluations will be integral to the selection of an appropriate light management option, as discussed in subsequent chapters of this manual.

Hatchling Arena Assays

The most scientifically reliable indication of whether or not a light is likely to cause problems for hatchlings can be obtained by performing a hatchling bioassay (Salmon et al., 1995). This technique involves the introduction of hatchlings into a specific lighting environment under controlled field conditions. The bioassays are essentially staged hatchling emergences, whereby a group of hatchlings is released into the center of a circular arena drawn in the sand. As the hatchlings crawl toward the periphery of the arena, their paths are recorded and later analyzed statistically to determine if they were significantly oriented toward the sea. The lack of significant orientation or a significant orientation away from the sea would be indicative of a lighting problem.

Because of the required manipulation of hatchlings, experienced professionals holding a valid marine turtle permit and prior written authorization from FWC are the only ones who can perform arena assays. Consequently, they are not widely used as an evaluation technique. Nevertheless, the tests can be very instructive in situations where large numbers of streetlights are located near a nesting beach. A well-designed bioassay program could be used to determine if an existing or newly installed lighting system is likely to cause problems for hatchling sea turtles before an actual disorientation event occurs. In cases where there is uncertainty as to whether or not streetlights are a potential problem, the bioassays may avert unnecessary modifications and expense. If, on the other hand, the tests indicate that lighting modifications are necessary, subsequent bioassays at the same location can be used to assess the effectiveness of corrective measures. Persons interested in determining whether arena assays would be appropriate for assessing their specific lighting problems should contact FWC.

CHAPTER 5

A STANDARD APPROACH FOR MINIMIZING LIGHTING IMPACTS

Basic Approach to Light Management

Although each street lighting problem may be unique, the approach to its resolution should be consistent. The most critical element of light management is the selection of the lighting alternative that most effectively reduces the potential for impacts to sea turtles while accommodating other public lighting needs. When evaluating lighting alternatives, three basic guidelines should be followed:

- Keep light off the beach.
- Minimize the total amount of illumination adjacent to the beach.
- Use light sources that are minimally disruptive to sea turtles.

This manual provides the best available technology (BAT) for accomplishing these objectives (Table 2). An overview of the step-by-step approach to the implementation of an effective street lighting solution is presented in Table 3 (Page 32).

Table 2

**Basic Objectives of Effective Streetlight Management,
Listed in Order of Importance**

| | Light Management Strategy | Methods |
|----------|---|---|
| 1 | Keep Light Off the Beach | Turn lights off, realign, modify, reposition, shield, or screen fixture from beach view |
| 2 | Reduce Total Luminance | Turn lights off, install fewer lights, reduce wattage |
| 3 | Minimize Potentially Disruptive Wavelengths | Install amber-colored lenses that filter out short-wavelength light or use LPS lights |

It is the ultimate responsibility of the light user (entity requesting and utilizing the service) to resolve identified street lighting problems. However, this usually cannot be accomplished without the cooperation and active participation of the lighting custodian (local utility or electric provider). As light managers, both users and custodians must be vigilant for potential problems and be sensitive to the needs and constraints of the other party. A balanced approach may also require consultation and cooperation among the light user, custodian, permitting authority, regulatory agencies (FWC and USFWS), and local environmental managers (city and county).

The complexity of a lighting problem should never be used as justification for lack of action. As discussed in the following chapters, a variety of alternatives are available for managing roadway lighting. If these are fully explored and evaluated, acceptable solutions to even the most complex lighting problems are likely to be found.

Keep Light Off The Beach

The first priority of light management is to keep light from reaching the beach, regardless of the spectral properties of the light source. Some light may be less disruptive than others, but all light has the potential to cause problems for sea turtles. Furthermore, different species respond differently to the various properties of light (brightness, color, etc.). Thus, while minimizing disorientations for one species, a selected lighting option may be ineffective for others.

If the lamp or any reflective surfaces of a streetlight are visible from anywhere on the beach, the light is likely to cause direct illumination of the beach. Fixtures can be realigned, modified, repositioned, and/or shielded to keep light from reaching the beach.

Reflected light (light indirectly reaching the beach from a light fixture such as that reflected off a nearby building) may also cause a problem for sea turtles. If streetlights are in close proximity to buildings, modifications to the fixture may be required, even if the source of light is not directly visible from the beach. Indirect lighting of the beach should be addressed in the same manner as for direct beachfront lighting. (See Chapter 4, Page 28, Item No 2 for a practical method of determining if reflected light is reaching the beach.)

Reduce Total Luminance

The second priority of light management is to reduce the total amount of luminance adjacent to the beach. Light that is cast or reflected skyward contributes to skyglow. Along the coastline, particularly on misty or cloudy nights, cumulative skyglow can cause problems for sea turtles. If lights in a street lighting system can be eliminated without sacrificing public safety, they should be turned off. A reduction in the wattage of street lamps will also reduce the potential for skyglow problems.

Table 3**Guidelines For Achieving Effective Street Lighting Solutions**

1. Ascertain that a problem exists. This can be accomplished through:
 - a. A proactive nighttime beach evaluation of roadway lights, or
 - b. Receipt of notification of a disorientation event attributed to a particular light.
2. For each problem light, determine the following, where possible:
 - a. Spatial extent of beach affected,
 - b. Brightness of light reaching the beach,
 - c. Approximate distance of light fixture from the beach,
 - d. Height of dune and extent of vegetative buffer along the section of beach affected by the light,
 - e. Type of fixture (e.g., drop globe, decorative streetlight, etc.),
 - f. Light source (type of lamp and wattage; e.g., 150W HPS lamp),
 - g. Mounting height,
 - h. Roadway type and lighting requirements,
 - i. Position of fixture relative to beach (e.g., facing toward or away from the beach), and
 - j. Utility pole identification number.
3. Determine who owns the light (custodian) and under whose authority the light is operated (permitting authority). The customer service representative for the local utility (account manager) should be able to assist in this matter. FPL-owned lights have an FPL logo on the light fixture.
4. Considering the type of roadway being illuminated, the amount of crime in the area, pedestrian usage, etc., work cooperatively with the lighting custodian, local regulatory agencies and municipal environmental managers to select the lighting alternative that best accommodates local concerns and public interests, while providing adequate protection for sea turtles. If numerous lights within a lighting system are causing problems, prepare a plan of action to address each.
5. Based on the alternative selected, determine if a lighting variance is needed from the permitting authority, and obtain lighting modification approvals, as necessary.
6. Implement the selected light management option.
7. Assess the effectiveness of the selected alternative.
8. Make additional adjustments, as necessary (i.e. fine tune the selected option or select another option) to minimize the potential for future lighting impacts.

Minimize Potentially Disruptive Wavelengths

It is not always possible to completely keep light off the beach while satisfying other public interests. Thus, the third step of light management is to minimize the amount of potentially disruptive wavelengths reaching the beach. Fixtures emitting only long-wavelength (550-700 nanometers) light are particularly useful in situations where street or security lighting is needed very close to the beach. Long-wavelength light sources require less broadcast precision than conventional light sources, because they are less likely to cause problems for hatchlings. LPS lighting, or amber-colored filters applied to conventional HPS light sources, may be used as an incremental measure when there is a need to keep the lights on, but when other lighting modifications fail to keep light completely off the beach.

Employ Best Available Technology

A common strategy for combating many types of pollution is to implement proven and effective pollution-reduction and pollution-prevention methodologies, often referred to as best available technology (BAT). In the context of light pollution, BAT simply implies that light managers use the best available means to minimize the potential for street lighting impacts to sea turtles.

This manual contains all of the tools and guidelines needed for an informed approach to light management. Although ingenuity will undoubtedly yield some options not contained in the manual, the most effective alternatives currently available have been identified and evaluated and are presented here.

If an existing technique for light management is not presented in this manual, it has probably been rejected as not meeting the criteria of BAT. For example, long-pass (dichroic) filters have been suggested as a method for attenuating harmful short-wavelength light (Witherington and Martin, 2000). These laminate filters can easily be applied to the inside of the glass lenses of existing fixtures. Unfortunately, under normal application they greatly diminish the efficiency of the fixture. Furthermore, they are only effective in filtering short-wavelength light that strikes the lens perpendicularly. At more oblique angles, the filtering properties diminish. For this reason, long-pass filters are not recommended for use within pole-mounted, high-intensity discharge luminaires adjacent to sea turtle nesting beaches.

Short-cuts to light management, such as painting or attaching aluminum foil to the seaward face of a fixture, are impermanent, ineffective, and may be unsafe. Halfway measures result in unnecessary effort and expense and delay resolution of the lighting problem. This delay may potentially result in additional take of sea turtles.

As new and innovative lighting alternatives are developed, they will be evaluated for effectiveness. Those that are demonstrated to be good alternatives will be included in future updates of this manual.

Evaluate the Selected Alternative

The final step in the light management process is to evaluate the effectiveness of the selected alternative. If possible, walk onto the beach and examine the light before and after the light management option is applied. Does it appear that the application has kept light off the beach or, at least, considerably reduced the amount of illumination reaching the beach? Can other options be applied to further reduce the potential for lighting impacts? A small adjustment or application of additional hardware before leaving the work site may eliminate the need for a return trip. This important final step will reduce the overall effort, expense, and/or aggravation associated with light management.

Planning and Design of New Street Lighting Systems

As with most environmental problems, the time and expense required to combat light pollution could be eliminated or considerably reduced through proper system design. Although the focus of this manual is on problem solving, it also provides an excellent opportunity for incorporating preventive measures into the design of new lighting systems. The basic objectives of light management presented in this chapter, as well as the alternative methods for managing light presented in Chapter 6, serve as appropriate design criteria. Potential lighting impacts should be considered in the planning and design of the following:

- New roadway lighting systems within direct line-of-sight of the beach.
- Renovations of existing lighting systems within direct line-of-sight of the beach (for example, see FDOT's Embedded Roadway Lighting Study, Page 26).
- Construction of new bridges near the coast.

The design criteria for new lighting systems is contained in the FDOT Plans Preparation Manual, a document authorized under section 334.044(2), Florida Statutes. When a lighting system is incorporated into a roadway improvement project, the FDOT Project Design Engineer refers to the Plans Preparation Manual for information on how to justify and design the system to applicable safety standards. Design elements include distance between poles, pole height, light source, wattage, illuminance, and clear zone requirements. The proximity of proposed lighting systems to environmentally sensitive areas is not always considered. However, there is a mechanism whereby the Project Design Engineer can request a design exception if variances from minimum safety standards are needed to reduce the potential for lighting impacts to sea turtles. This requires coordination with the Federal Highway Administration. Guidelines for seeking design exceptions and variances are contained in the Plans Preparation Manual, Volume I, Chapter 23.

Copies of FDOT's Plans Preparation Manual can be ordered from: FDOT Maps and Publications Sales, 605 Suwannee Street, Mail Station 12, Tallahassee, Florida 32399-0450 or from FDOT's web site at <http://www11.myflorida.com/mapsandpublications>

The FDOT Plans Preparation Manual Volume I, Chapter 23: Design Exceptions and Design Variations discusses how to obtain a design variation. When designing a lighting system that does not meet current FDOT Lighting Standards, the designer should request a Design Variation from the FDOT District Design Engineer. The request should be categorized as (Other) when completing the Request Form found in the FDOT Plans Preparation Manual. When requesting a design variance, the applicant should provide a statement that identifies the impact lights have on sea turtle nesting beaches. Provide a statement that laws under the U.S. Endangered Species Act of 1973 and Florida Statutes prohibit activities that harm or interfere with sea turtle behavior. If the alternative lighting design is in a county that has a County Lighting Ordinance, provide a statement that identifies the ordinance and that the alternative lighting design is an effort to comply with the ordinance. Each request for a Design Variation will be reviewed on a case-by-case basis.

Through a combination of careful light placement and best available lighting technology, it may be possible to design new coastal roadway lighting systems that meet minimum safety standards yet pose minimum risk to sea turtles on adjacent nesting beaches. Coastal roadways in Florida also provide an excellent opportunity to test new technologies such as light-emitting diodes (LED) imbedded in the roadway surface. These and other advances may one day supplant conventional roadway lighting adjacent to important nesting beaches.

Reasons for Managing Lights Rather Than Manipulating Eggs and Hatchlings

Questions frequently arise as to why lights must be modified to protect sea turtles. Why can't we simply move the nests to darker areas of the beach? There are numerous, sound reasons why state and federal agencies responsible for sea turtle conservation and recovery programs discourage manipulative programs as a substitute for light management.

Nest relocation has been utilized in the past to manage lighting impacts to marine turtle hatchlings. Relocation of eggs to a controlled hatchery or to darker areas on the beach is no longer authorized by FWC. The few communities with exceptions to this restriction are working to improve light management and reduce the number of nests relocated annually. Relocation programs are time-consuming, costly, and ultimately may not be in the best interests of sea turtle conservation. Because it is not possible to find and relocate every nest, particularly by 9 AM as required by FWC, some turtle hatchlings will still be vulnerable to lighting impacts, and thus, there is a probability that take will occur. In addition, poor light management reduces the frequency of emergences by nesting females onto the beach. This constitutes take under the ESA, because it interferes with essential breeding behavior. Light pollution diminishes the suitability of available nesting habitat and may force turtles to utilize less appropriate nesting sites (Murphy, 1985).

The process of egg relocation poses risks; mortality occurs if eggs are broken or developing embryos are disrupted during movement (Limpus et al., 1979). Data from several nesting beaches in Florida suggest that the percentage of hatchlings emerging from the nest (emerging success) is reduced for relocated nests when compared to nests left in

place (Moody, 1998). Those nests that are relocated to a centralized hatchery are susceptible to natural catastrophes, such as storms, that could destroy a disproportionately large percentage of a beach's annual reproductive output. Eggs and hatchlings in a centralized location are also more susceptible to disease, parasites, and predators. There are also potential sub-lethal effects, such as disruption of critical cues imprinted by hatchlings while still in the nest and/or during their migrations from the nest to offshore habitats. Best available scientific data support the long-held belief that female sea turtles return to their natal beaches to lay their eggs (Bowen and Karl, 1997). Manipulation of eggs and hatchlings could potentially interfere with these imprinting mechanisms.

Another management technique that has been used to protect hatchlings from lighting impacts is caging. Screen cages are placed over the nests as they near hatching and checked periodically during the night. Hatchlings confined by the cage are collected and released at a dark beach. This too has its drawbacks. Excessive crawling by confined hatchlings prior to their release expends valuable energy needed during their offshore migrations. As for nest relocation, some nests are likely to be missed during morning surveys, and hatchlings from these nests are at risk from light pollution. Similarly, nest caging does not resolve the issue of nesting habitat degradation caused by artificial lighting.

Nest relocation and caging can be performed only by qualified individuals holding a valid marine turtle permit and written authorization from FWC. The circumstances that warrant manipulative protective measures and the conditions attached to the FWC authorization for such measures are detailed in guidelines issued to the permit holder.

Because of the potential liabilities associated with nest relocation and caging, current conservation philosophy advocates light management as the best strategy for minimizing lighting impacts to sea turtles. Effective light management can be practically implemented in most coastal settings. When properly applied, the techniques contained in this manual will substantially reduce, if not eliminate, the need for manipulative programs allowing nests to be left in place and the reproductive process to occur naturally without human intervention.

CHAPTER 6

ALTERNATIVES FOR MANAGING EXISTING ROADWAY LIGHTING

Management of roadway lighting can be more complicated than managing beachfront lighting on private property because of the various issues and parties potentially involved. However, effective light management is not technically difficult nor is it necessarily expensive. Simple, inexpensive solutions are often very effective.

Because of the complexity of social needs and environmental settings throughout coastal areas, no specific lighting option is likely to be appropriate for every problem. In this chapter, a variety of alternatives for reducing street lighting impacts to turtles are presented (Table 4). Table 5 shows the relative effectiveness of different lighting alternatives in addressing various street lighting issues.

Some alternatives may effectively resolve a lighting problem when used independently, while other problems may require a combination of alternatives. Some alternatives may be adequate as temporary solutions, while other more complex and permanent solutions are under evaluation.

An important consideration to keep in mind is that any modification to streetlights may alter the amount and distribution of light on the roadway. This will require an approval from the authority that has permitted the lighting system. The criterion used by FDOT in assessing whether a variance or waiver from lighting standards is required is the effect the modification is expected to have on highway safety (see Chapter 3, Page 17 *Altering Roadway Lighting Systems*). Because the combination of lighting environments, highway usage patterns, and lighting alternatives is so variable, there are no clear tests that can be offered to determine if a selected alternative will or will not require a variance. This can only be determined through consultation with the permitting authority.

Table 4

List of Options¹ That Can be Used Independently or in Combination to Reduce Street Lighting Impacts to Sea Turtles

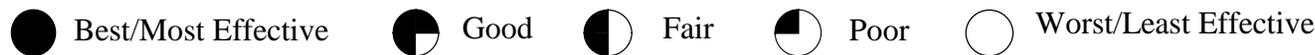
- Realign the fixture (change angle of mounting arm or rotate fixture head) so the source of light is not directly visible from the beach.
- Apply a shield to a drop globe fixture.
- Change an open bottom or drop globe fixture to a cutoff fixture.
- Apply a shield to a cutoff fixture.
- Reduce the mounting height of the fixture.
- Reduce the lamp wattage.
- Change the lamp socket position in the fixture to compress the lighting footprint.
- Change to a fixture with a different type of reflector providing a more favorable lighting footprint.
- Install a flat 2422 acrylic amber lens in a cutoff fixture with an HPS lamp of 70 watts or less (e.g., GELS 70W M250). This option should only be used in addition to keeping light off the beach and reducing total luminance.
- Turn the light off.
- Remove the fixture.
- Relocate the fixture to block light from beach view.
- Move the fixture to the ocean side of the roadway so that light is broadcast away from the beach.
- Change to an LPS fixture (if the light is customer-owned).
- Create a vegetated dune buffer.
- Erect an artificial light shield between the light and the beach.

¹ Not listed in any particular order.

Table 5

Relative Effectiveness¹ of Lighting Alternatives (Used Independently) in Accommodating Various Street Lighting Interests

| Lighting Alternative (Used Independently of Other Alternatives) ² | Sea Turtle Protection | FDOT Lighting Standards | Traffic & Public Safety | Color Rendition | Ease of Application | Initial Cost | Operating Costs | Maintenance Costs |
|--|-----------------------|-------------------------|-------------------------|-----------------|---------------------|--------------|-----------------|-------------------|
| Remove Fixture | ● | ○ | ○ | ◐ | ◐ | ◐ | ● | ● |
| Turn Off Light | ● | ○ | ○ | ◐ | ● | ● | ● | ● |
| Shielded Cutoff Fixture | ◐ | ◐ | ◐ | ● | ◐ | ◐ | ◐ | ◐ |
| Shielded Drop Globe Fixture | ◐ | ◐ | ◐ | ● | ◐ | ◐ | ◐ | ◐ |
| Install Cutoff Fixture | ◐ | ◐ | ◐ | ● | ◐ | ◐ | ◐ | ◐ |
| Alter Transverse Light Distribution | ◐ | ◐ | ◐ | ● | ◐ | ◐ | ◐ | ◐ |
| Reduce Fixture Height | ◐ | ◐ | ◐ | ● | ◐ | ◐ | ◐ | ◐ |
| Realign Arm Bracket | ○ | ◐ | ◐ | ● | ◐ | ◐ | ◐ | ◐ |
| Reposition Fixture Behind Structure | ◐ | ◐ | ◐ | ● | ○ | ○ | ◐ | ◐ |
| Orient Fixtures Away from Ocean | ◐ | ● | ● | ● | ○ | ○ | ◐ | ◐ |
| Reduce Wattage | ◐ | ◐ | ◐ | ● | ◐ | ◐ | ◐ | ◐ |
| Cutoff Fixture with Acrylic Lens | ◐ | ◐ | ◐ | ◐ | ◐ | ◐ | ◐ | ◐ |
| LPS Lighting | ◐ | ◐ | ◐ | ○ | ◐ | ◐ | ○ | ○ |
| Install Light Barrier | ◐ | ● | ● | ● | ○ | ○ | ◐ | ◐ |


 ● Best/Most Effective ◐ Good ◑ Fair ◒ Poor ○ Worst/Least Effective

¹ A “best” and “worst” are listed for each category. However, unlisted alternatives may rank higher or lower than those listed.

² Unless otherwise stated, the alternative is used in conjunction with conventional HPS lighting.

Selectively Eliminate the Light Source

The simplest and most certain way to eliminate the potential for street lighting impacts to sea turtles is to eliminate the light source. Depending on social needs associated with a particular light, the following options are available: (NOTE: Any modification or alteration of light levels on a roadway must be approved by the appropriate agency, i.e. DOT, county, etc.)

- a. If a light can be eliminated without appreciable social impact, remove the fixture. This will ensure that the light is not inadvertently turned on during the nesting season.
- b. If seasonal lighting is desirable, turn the light off during the sea turtle nesting season. This allows roadway lighting during the fall and winter months, the period of heaviest traffic in many coastal areas of Florida, while protecting turtles during the spring and summer months.
- c. If the light is critical to year-round traffic safety, turn the light off during the period that nearby nests are expected to hatch. This approach is the least desirable, because it:
 - Does not address lighting effects on nesting turtles.
 - Requires coordination with sea turtle monitoring personnel to identify periods when the light should be turned off.
 - Requires an assessment as to what constitutes a “nearby” nest. (i.e., What is the spatial extent of influence of the light in question? Each lighting situation is unique and therefore there is no standard guideline.)
 - Does not provide protection to hatchlings emerging from missed nests.
 - Requires that the lighting custodian is available and can be responsive to user requests for assistance. In cases where a roadway lighting system includes a large number of potential problem lights, the selective turning off and on of lights near nests may not be feasible.

Elimination of as many sources of light as possible along the coast is a desirable goal for sea turtle conservation. However, the location and numbers of lights to be eliminated must be determined on a community-by-community basis with consideration given to local social needs. Typically, lights are turned off or the fixtures eliminated when:

- a. The fixture is very close to the beach and there is little vegetative dune buffer to keep the light off the beach.
- b. Other lighting options prove ineffective.

Shield the Light Source

A relatively simple solution to lighting problems is to modify the fixture to shield the light source (bulb, lamp, etc.) from beach view. A variety of commercial shields are available for this purpose. When determining which type of shield to use consider the following: (NOTE: Any modification or alteration of light levels on a roadway must be approved by the appropriate agency, i.e. DOT, county, etc.)

- a. The shield should be deep and wide enough to prevent the light source from being visible from anywhere on the beach. Often, shields are effective in preventing light from reaching the beach due seaward of the fixture, but the light source can still be seen from locations farther up or down the beach. Unless the fixture is mounted very high, a shield having an arc of 180° and a depth of 8 inches will resolve most lighting problems.
- b. Shields attached to fixtures can add increased stresses to the fixture and bracket during high winds. Electric utilities must comply with the wind speed requirements as dictated by the National Electric Safety Code (NESC). These requirements vary by location (see Figure 3). The wind speed requirements for other entities, such as municipalities and individuals, are dictated by other governmental agencies.

Shielding of light fixtures is typically effective by itself when lights are a considerable distance from the beach or when a light source is only visible from a few areas near the dune. As the distance of the fixture from the beach decreases, shields are often used in combination with other alternatives.

If external commercial shields are inadequate or are not available for a particular style of fixture, consider fabrication of specially designed shields. These can be fashioned of aluminum to meet specific attachment, depth and/or arc requirements. However, this should be done only in consultation with the lighting custodian. Electric providers have policies against installation of non-conforming equipment/materials to fixtures in their roadway lighting systems. Shields should be firmly attached to the fixture so they aren't blown off during storms, and periodically inspected to ensure that they are functioning properly.

In cases where decorative, carriage-style fixtures are used along streets, internal sleeves can be applied. These can be custom made at relatively little expense out of PVC. As for external shields, the sleeve should be of sufficient arc and height so the light source is not visible from anywhere on the beach. The lighting custodian must be consulted in the design and application of this fixture modification.

Several alternatives to shielding have been used in the past. These include painting the seaward face of the fixture or placing aluminum foil or other opaque material in the interior seaward face of the fixture. Neither is recommended.

Some colors of paint allow light of undesirable wavelengths to pass through. Even black paint is not completely opaque. Paints deteriorate over time and thus require ongoing maintenance. During periods when the paint chips or cracks, potentially detrimental light may reach the beach and cause take of sea turtles.

Materials placed inside fixtures may alter the performance of the fixture or cause overheating. Metal sleeves placed inside the seaward side of open-bottom fixtures are typically inadequate to resolve lighting problems unless the fixture is a considerable distance from the beach.

Change or Modify the Fixture

Several adjustments can be made to fixtures to minimize their potential for causing direct illumination of the beach. (**NOTE:** Any modification or alteration of light levels on a roadway must be approved by the appropriate agency, i.e. DOT, county, etc.). These include:

Compress the Lighting Footprint

The better light is confined to the area of its intended use, the less likely it is to cause problems for sea turtles. The photometric properties of a streetlight (geometric pattern of light on the ground and variation in brightness within the pattern, hereafter referred to as lighting footprint) can be improved by replacing an open bottom or drop globe fixture with a cutoff or hooded fixture. This compresses the lighting footprint by concentrating light on the roadway, thereby reducing the amount of light reaching the beach. Cutoff fixtures include both shoebox and cobrahead designs. Shields attached to these fixtures further confine the lighting footprint.

Cutoff fixtures are typically effective in managing light from fixtures located a block or more away from the beach. They may also be appropriate for streetlights closer to the beach, if the lights are only visible from a few locations near the dune.

A combination of cutoff fixture and shield will usually resolve all but the most serious of lighting problems. For lights very close to the beach, additional modifications may be necessary.

Alter the Light Distribution

Another method of affecting the lighting footprint is by changing the fixture to one with a different type of reflector or changing the lamp socket position within the existing fixture. The type of reflector used and the position of the lamp in relation to the reflector affect the way light is distributed away from the source, both longitudinally and transversely. Longitudinal distribution refers to the amount of light cast up and down the street (i.e. perpendicular to the mounting arm of the fixture). Typically, a medium longitudinal pattern is used to maximize the spacing between fixtures, while maintaining good uniformity of light distribution on the roadway surface. If uniformity of light

distribution can be compromised, fixtures having a long longitudinal pattern will require fewer lights to illuminate the street.

The transverse distribution of light refers to how far light travels across the roadway (i.e. parallel to the mounting arm of the fixture). Fixtures with Type I, II, and III reflectors have relatively narrow transverse properties (Table 6). For streetlights facing the ocean, this is preferable to the broad transverse footprints produced by other types of reflectors.

With a Type I reflector, light distributions on the street side and back side of the fixture are identical; with Type II and III reflectors, light is offset towards the street side (Table 6). Having good backside cutoff properties is ideal for streetlights located on the seaward side of roadways. Depending on their distance from the beach and mounting height, utilization of Type II or III reflectors in fixtures facing away from the ocean may be sufficient to prevent direct illumination of the beach.

Use Non-Reflective Interior Surfaces

Adding an internal shield, a dark non-reflective material, to a fixture may substantially reduce the size of the lighting footprint and thereby minimize the amount of light cast toward the beach. Only internal shields approved by the fixture manufacturer should be used, as these may affect the operational safety and performance of the fixture.

Realign the Fixture

Often times the realignment of a fixture may be sufficient to prevent light from reaching the beach. This can be accomplished by altering the mounting angle of the fixture on the mounting arm so light is directed down or away from the beach. If the fixture is parallel to the roadway surface or bent at a slight angle toward the road, the potential for light reaching the beach is less than if the fixture were at an obtuse angle. Realignment of fixtures is generally most effective for fixtures relatively distant from the beach.

Reduce the Mounting Height

The higher a light is mounted above the roadway surface, the greater the potential for lighting problems. A reduction in mounting height alone will often resolve problems for fixtures relatively distant from the beach. For serious lighting problems near the beach, a reduction in mounting height should be the first consideration in a combination of light management efforts. This alternative must be carefully reviewed by the lighting custodian and regulators for conformance to roadway safety standards.

Table 6

Light Distribution Patterns (Lighting Footprints) For Streetlights

A luminaire is classified according to its light distribution pattern. This classification system was established by the Illuminating Engineering Society (IES). The designation consists of three components selected from the following columns:

| LONGITUDINAL LIGHT DISTRIBUTION* | LUMINAIRE CUTOFF CLASSIFICATION* | TRANSVERSE LIGHT DISTRIBUTION* |
|-------------------------------------|---|---------------------------------|
| (S) Short (M) Medium (L) Long | (F) Full Cutoff Type (C) Cutoff (S) Semi-cutoff (N) Non-cutoff | (I), (II), (III) (IV) or (V) |

*The letters in parenthesis are generally used to describe the classification.

a. Longitudinal Light Distribution

The short, medium or long designations are used to indicate how far the luminaire tends to direct light in the longitudinal direction; i.e., up and down the street. Generally a "medium" pattern will produce maximum spacing. Occasionally a "long" pattern will be best in a local-residential application where a less restrictive uniformity ratio is allowed. A "short" pattern would produce somewhat higher foot-candles in those instances where the poles have been spaced relatively close together; i.e., less than 4.5 mounting heights apart. Maximum fixture spacing will generally be less than:

| | | |
|--------|---|-----------------------|
| Short | - | 4.5 mounting heights |
| Medium | - | 7.5 mounting heights |
| Long | - | 12.0 mounting heights |

b. Luminaire Cutoff Classification

The full cutoff, cutoff, semi-cutoff and non-cutoff designations are used to describe how much light is allowed at 80% and 90% above nadir. See ANSI/IESNA RP-8-00 for complete definitions.

**Table 6.
(Continued)**

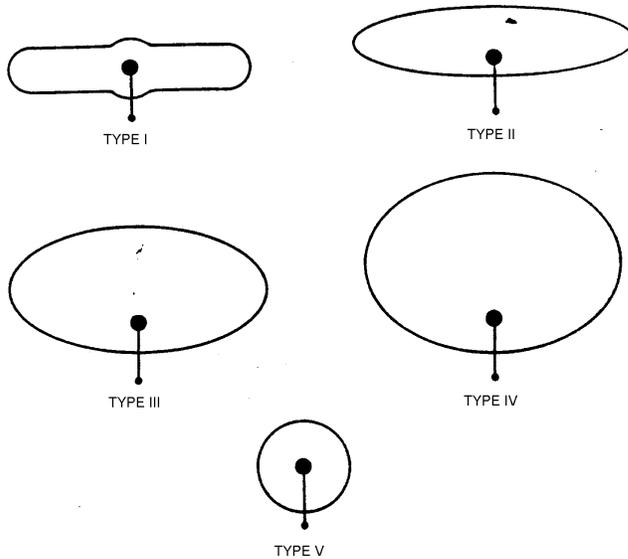


Figure 1
Transverse Light Distribution Types

c. Transverse Light Distribution

The Type I, II, III, IV or V designations are used to indicate how far the luminaire tends to direct light in the transverse direction; i.e., across the width of the street. See Figure 1.

The Type I is a narrow beam pattern. The house side light distribution pattern and the street side light distribution pattern are identical. This distribution type should be used where the road width does not exceed 1 mounting height.

Type II distribution has a narrow beam pattern with an offset towards the street side. This distribution type should be used where the road width does not exceed 1.75 times the mounting height. For example, if the luminaire was mounted at 25', then the road width should not exceed 44'.

Type III distribution is a wider Type II light distribution pattern intended for use where the street width does not exceed 2.75 times the mounting height of the luminaire. For example, if the luminaire was mounted at 25', then the road width should not exceed 69'.

Type IV distribution is an even wider light distribution pattern that is used for street widths that exceeds 2.75 times the mounting height of the luminaire. If the luminaire were mounted at 25', then the type IV pattern would be good for streets that are wider than 69'.

Type V distribution is a nondirectional light distribution pattern. The pattern is a circle. This type is used for general area lighting.

Relocate the Light Source

In some instances light can be better controlled by moving the fixture to another location. Light management can be effectively achieved by:

- a. Moving the fixture to a location where buildings or other light barriers shield the light from beach view.
- b. Moving the fixture a greater distance from the beach, so the seaward edge of the lighting footprint is moved off the beach.
- c. Moving the fixture to the ocean side of the roadway. This often permits better light management because many shields and fixtures are designed for light cut off on the backside of the streetlight. Additionally, the fixture head can be tilted to move the seaward edge of the lighting footprint further away from the beach. Light that is directed away from the beach typically will cause fewer problems than light directed toward the beach.

Because of the expense and effort involved, relocation of streetlights is typically a measure of last resort for resolving the most serious lighting problems. However, light positioning should be a high priority in the planning of new installations and in the retrofitting of existing systems as they become obsolete. If repositioning of light poles is to occur seaward of the Coastal Construction Control Line (CCCL), a permit application must be submitted to FDEP prior to any construction activities.

Information on FDEP's Coastal Construction Control Line permit program can be found at www.dep.state.fl.us/beaches/programs/ccclprog.htm

Reduce Total Illumination

Where sea turtles are concerned, less light is better. An overall reduction in levels of luminance (lumens) can be achieved by:

- a. Reducing the wattage in fixtures used for coastal roadway lighting, and
- b. Reducing the total number of lights used in the system to those that are absolutely essential.

Change Spectral Qualities of Light Source

Fixtures that emit light that is minimally disruptive to sea turtles are preferred over broad-spectrum light sources. This can be accomplished through the use of the following:

Filtering Lenses

Filters that alter light characteristics in a manner that reduces their attractiveness to hatchlings have practical appeal. As the result of efforts to identify such filters, a variety of lenses were tested. The results of these tests, which are presented on Page 25, provided mixed indications. To date, none have demonstrated reduced effects sufficient to warrant substituting filters for other light management techniques.

Low-pressure Sodium Vapor (LPS) Light Fixtures

LPS lamps emit monochromatic yellow light. At high luminance levels, loggerhead turtles have an aversion to this type of light. At lower levels, it is weakly attractive to all species. Advantages and disadvantages of LPS have been discussed elsewhere (see Chapter 3, Page 23).

Plant Vegetative Buffers

Keeping light off the beach is the number one priority of light management. The installation of light barriers should, therefore, be a high priority in those areas where coastal roadways run immediately adjacent to the beach and there is no dune or vegetation to block light. Removal or substantive trimming of existing dune vegetation should be strongly discouraged by local governments. Dune restoration and revegetation projects should be a key element of new roadway design. Establishment of natural light barriers should also be considered in those areas with long-term shoreline protection/beach preservation programs. All beach renourishment projects should incorporate this element into project design. A good vegetative dune buffer will eliminate many lighting problems. Synthetic light barriers may be appropriate in those situations where aesthetics is not an important consideration and light management is extremely difficult. Any construction, including the establishment of vegetative or synthetic light barriers seaward of the Coastal Construction Control Line (CCCL), must be approved by the Florida Department of Environmental Protection (FDEP).

Information on FDEP's Coastal Construction Control Line permit program can be found at www.dep.state.fl.us/beaches/programs/ccclprog.htm

Implement Other Technologies

Other new and innovative street lighting technologies may become available after this manual is initially distributed. Those proven to be effective in further reducing impacts to sea turtles should be added to the alternatives presented in this chapter. To the greatest extent practicable, updates of the manual will be made available to all interested parties electronically through FWC's web site at:

<http://floridaconservation.org/psm/turtles/manual.pdf>

The manual is designed such that obsolete pages can be easily removed and new information substituted in its place. Periodically, subscribers should check the FWC web site to determine if they are using the most recent version.

CHAPTER 7

SELECTING THE APPROPRIATE ALTERNATIVE

The principal that has been applied to the alternative selection process in this manual is to begin with the most basic and simplest solutions and progress to more complex and difficult solutions. For example, if a light fixture a considerable distance from the beach is identified as a problem, the first step would be to realign or shield the light. If that proves ineffective, then the fixture should be replaced with a cutoff style fixture. That too may require shielding. If the light is very bright and mounted high on a pole to meet roadway lighting standards, an amber filter may be needed in addition to the other adjustments. With experience, the lighting custodian should be able to determine the extent of modifications necessary to effectively resolve the problem, without having to return several times to make additional modifications. Local, state, and/or federal environmental managers should be used as a resource in developing effective solutions.

In evaluating and selecting lighting alternatives, some general guidelines are offered for achieving light management goals. The potential for lighting impacts to sea turtles is reduced as the:

1. Distance of the streetlight from the beach increases,
2. Mounting height of the light fixture decreases,
3. Luminance (brightness) of the lamp decreases,
4. Total number of fixtures used in the street lighting system decreases (cumulative impact),
5. Photometric properties of the light fixture are altered to reduce the size of the lighting footprint,
6. Extent of natural or man-made shielding (light blocking) increases,
7. Fixture is rotated to face away from the beach, and
8. Amount of short-wavelength light emitted decreases (by using amber-colored light filters or LPS lights).

Below is a basic guide to the selection of a light management alternative for most standard roadway lighting problems. Each light management option should be evaluated after modifications have been made to ensure that the selected option is effective.

Is the Light Visible From the Beach?

Both direct and indirect illumination of the beach may cause disorientation of sea turtle hatchlings, and both types of lighting problems must be addressed. Although streetlights that cause direct illumination of the beach are typically the most serious of the two, both can be addressed by implementing one of the lighting alternatives offered in this section.

A conservative approach is to consider that a light is causing direct illumination of the beach, if the source of light or any reflective surfaces of the fixture can be seen from anywhere on the beach. Chapter 4, Page 28 (Item No 2) presents a practical method for determining if reflected light is reaching the beach. For direct lighting, modifications are directed toward keeping the light from shining onto the beach. The objective of modifications to reduce indirect beach illumination is to keep light off nearby reflective surfaces.

If a street lighting system consists of many lights within direct line of sight of the beach, even if none of the lamps is directly visible from the beach, an overall reduction in luminance is recommended. This will reduce the potential for cumulative lighting impacts such as skyglow. An overall reduction in the amount of light adjacent to the beach can be accomplished by reducing the wattage of lamps within the lighting system and/or by reducing the total number of lights turned on.

Distance of Light From the Beach

The intent of light management is to confine light landward of those areas where sea turtle nests are deposited. The landward extent of nesting habitat is usually the line of permanent dune vegetation. In the absence of a well-defined dune system, nesting may occur anywhere where sufficient areas of open sand are present. Along beaches where erosion control structures are present (e.g., seawalls, rock revetments, etc.), the structure itself usually establishes the upland boundary for nesting. In the context of light management, beach is used to denote the spatial extent of sea turtle nesting habitat.

Lights More than 300 Feet From Beach

The farther the light is located from the beach the greater the flexibility in addressing the problem. For lights greater than 300 feet from the beach, simple solutions will most likely prove effective. Sometimes, a fixture might only have to be realigned (tilted down or to the side) to completely eliminate the problem. Shields applied to any type of fixture should take care of most remaining problems at this distance. If the light is particularly high or bright or if there is little in the way of dune buffer to shield it from beach view, a cutoff fixture may be required. If the problem light is already a cutoff fixture, apply a shield and/or amber lens. (*see Table 7A, Page 58*)

Lights 100 to 300 Feet From Beach

At intermediate distances (200 to 300 feet), many of the techniques referenced above still apply. The alternative selected will depend largely on how much illumination is reaching the beach. If relatively little light is visible from the beach, shielded cutoff fixtures are probably all that is required. As either the mounting height or wattage of the fixture increase or the amount of dune vegetation buffer decreases, amber lenses should be added. However, if large areas of beach are being illuminated, a reduction in mounting height and lamp wattage may be required along with a change out of prismatic drop globe fixtures to shielded cutoff fixtures.

Between 100 and 200 feet from the beach, fewer lighting options will be effective, and some major modifications may be required. However, if a good dune buffer is present, changing to a shielded cutoff fixture may be sufficient. Where high wattage lamps are mounted high on the pole, first attempt to reduce the wattage and mounting height before undertaking any other adjustments. Then try either a shield or a combination of shield and cutoff fixture. Where considerable light is reaching the beach, the lighting distribution may be improved by changing the fixture to one with a different type of reflector or by adjusting the lamp socket position within the fixture. Light directed away from the beach is usually easier to keep off the beach than light directed toward the beach. If there is sufficient room on the seaward side of the highway and little or no dune buffer is present, relocation of the fixtures to the seaward side of the street may greatly improve the light management effort. In any case where lights are fairly close to the beach, the application of shielded cutoff fixtures with amber lenses is recommended. (*see Table 7B, Page 59*)

Lights Within 100 Feet of Beach

At distances closer than 100 feet from the beach, difficult choices sometimes have to be made. Depending on the local setting, turning the light off may be the only way to ensure that lighting impacts will not occur. If turning the light off is not an option, it becomes increasingly important to modify the spectral properties of the light being emitted, because it may not be possible to prevent all light from reaching the beach. Any light that reaches the beach should be minimally disruptive to sea turtles.

It is important to remember that the principal objective of light management is to keep light off the beach. Even if spectral properties are altered (amber lenses or LPS), the fixtures should be shielded or modified to confine the lighting footprint landward of the primary dune. For example, consider a HPS lamp in a drop globe fixture located at the end of a road terminating only 50 feet from the beach. If by changing the fixture to a shielded cutoff fixture with a compressed lighting footprint, we could keep all light from reaching the beach, this would be preferable over allowing filtered light to illuminate the beach. In other words, changing the spectral properties of a light source should never be used as a substitute for keeping light off the beach. However, if the lighting modifications described above continue to allow some light to reach the beach, then spectral quality modifications should be implemented as well.

The distributional properties of LPS light are more difficult to manage than those of conventional HPS fixtures. For this reason amber filtering lenses in directional streetlights (e.g., Cobrahead cutoff fixtures) are preferable for those cases where modifications will largely, but not completely, confine the lighting footprint landward of the beach. However, the spectral properties of LPS light are superior to those of filtered light. Thus, in those cases where a streetlight is very close to the beach and lighting modifications cannot effectively maintain the lighting footprint landward of the dune, LPS would be a superior choice.

Establishment of a thick vegetated dune buffer along those sections of beach in close proximity to a lighted roadway is one of the most effective long-term light management options for keeping light off the beach. The worst lighting problems typically occur in those areas where there is little or no dune vegetation. Temporary light screens set up between nearby streetlights and nests ready to hatch can also be used if coastal aesthetics are not an issue. These screens are typically constructed of a double layer of shade cloth (used by plant nurseries) secured to a line of tall posts placed along the dune crest. FDEP and local approvals must be obtained prior to construction of either natural or synthetic light barriers to ensure that these systems are properly planned, constructed, and maintained. (*see Table 7C, Pages 60 & 61*)

Type of Fixture

The more control a light manager has over the photometric properties of a fixture, the better he/she will be able to keep light off the beach. Cutoff fixtures are better than open bottom or drop globe fixtures in confining the lighting footprint. The combination of fixture style and photometric properties selected will depend on the orientation of the street and streetlight relative to the ocean. If a street runs perpendicular to the beach longitudinal light distribution will be more important than transverse distribution. The opposite applies to streets that run parallel to the ocean. Light can be better controlled if a fixture is directed away from the beach. Cutoff fixtures become increasingly important in light management as the distance of the fixture to the beach decreases.

Mounting Height and Wattage

In order to maintain an acceptable level of light on the roadway and keep the number of fixtures to a minimum, increased mounting height and higher lamp wattages are typically used in roadway lighting designs. Unfortunately, as mounting heights and wattages increase, the potential for beachfront illumination increases. Thus, a first step in addressing a lighting problem is to determine whether a reduction in mounting height and wattage can be undertaken without compromise to an acceptable level of highway safety. Where it is not possible to alter the lighting configuration, a combination of amber lenses and shields may be an acceptable alternative. If the subject lights are relatively close to the beach, installation of light screens or establishment of natural dune barriers may be required to keep the light off the beach.

Extent of Beach Illumination

The amount of effort required to resolve a lighting problem is directly related to the amount of light reaching the beach and the spatial extent of illumination. If a streetlight is only visible from a few locations near the dune, simple shielding may be effective. In other cases a combination of cutoff fixture and shield may be required. If the light is very close to the beach, even if only visible from a few locations, the addition of an amber lens would be appropriate. This will offer additional protection, in the event that dune characteristics change (e.g., vegetation dies, beach profile changes, etc.).

If a streetlight is visible from numerous locations both near the dune and the waterline, a combination of shielded cutoff fixture with amber lens will probably be required. Depending on the distance of the fixture from the beach a reduction in mounting height and wattage may also be appropriate.

In the most extreme cases where bright lights are very close to the beach and there is little dune buffer, large sections of beach may be brightly illuminated. In these cases, the lights must either be turned off, the spectral qualities altered, or artificial light barriers erected. Establishment of a natural vegetated dune buffer would probably allow for the use of shielded cutoff fixtures with amber lenses instead of LPS.

Summary of Lighting Options

As indicated above, there are a number of factors involved in determining which alternative is appropriate for resolving a particular lighting problem. It is impractical to list all of the potential combinations of variables that could be considered in the selection of a lighting solution.

- Table 4 lists the available options that can be used either independently or in combination to resolve identified lighting problems.
- Table 5 indicates the effectiveness of each lighting alternative, when used independently, in addressing various street lighting issues.
- Table 7 summarizes the alternative selection process and provides examples of appropriate solutions for selected lighting conditions.

Table 7**The Alternative Selection Process**Explanation of Table

This table is designed to assist in the selection of a lighting modification that is *likely* to resolve your street lighting problem. In selecting one of the alternatives, there are two important considerations:

1. ***The recommended modification may not be 100% effective for your specific lighting problem.*** Each lighting situation is unique depending on the purpose of the light, the type of fixture, the wattage of the lamp, the distance of the fixture from the beach, the linear extent and height of natural barriers and buildings between the light and the beach, etc. While the alternative selected from the table will undoubtedly *reduce* the potential for lighting impacts to sea turtles on adjacent beaches, it is not guaranteed to be 100% effective for every lighting problem. For that reason, it is important to evaluate your problem light after the modifications have been made to ensure that the selected option has adequately achieved light management objectives. (See Chapter 4, Page 27 for guidelines for performing nighttime lighting evaluations).

Light management objectives have been achieved if:

- The source of light (bulb, lamp, etc.) is no longer directly visible from the beach.
 - Light is not indirectly reaching the beach from reflective surfaces near the light source.
 - The total amount of luminance adjacent to the beach has been reduced to the minimum required to comply with highway safety standards.
 - Any light reaching the beach has spectral properties that are minimally disruptive to sea turtles.
2. ***The recommended modification may be more involved than is necessary for your specific lighting problem.*** The recommended modifications in the table are conservative. They were developed to ensure that an effective solution will *likely* be achieved. In many cases, depending upon the specific lighting situation, a simpler, less expensive alternative may be just as effective as the recommended modification(s). Therefore, prior to undertaking a modification, a site-specific assessment of the lighting environment should be made (see Table 3, Item No. 2, Page 32). This, together with consultations with local environmental managers and/or lighting experts, may reduce the effort and expense associated with implementation of an effective solution.

How to Use the Table

Step 1. Determine how far the problem light is from the beach and go to the appropriate sub-table to select a lighting alternative.

As indicated throughout this manual, there are a number of variables that will determine which modifications will be most effective for your particular lighting situation. In this table, distance from the beach is the first principal determinant. Lights that are very close to the beach will require considerably more effort to correct than those farther inland. The distances selected for the table are somewhat arbitrary, but should provide a relative gauge of the effort that is likely to be required to achieve light management objectives.

- a. Light fixture more than 300 feet from the beach Use Table 7A
- b. Light fixture 100-300 feet from the beach Use Table 7B
- c. Light fixture within 100 feet of the beach Use Table 7C

Step 2. Go to the section of the table that best characterizes the community setting where the light is located (rural or urban).

Typically there is more flexibility in addressing lighting problems in rural areas than in more urbanized settings where there may be greater concerns about pedestrian safety.

Step 3. Under the appropriate community setting, go to the section of the table that is closest to the mounting height and lamp wattage of the fixture being modified.

The higher the light is off the ground and the brighter the lamp, the greater the potential for causing problems for sea turtles. Bright lights mounted relatively high will require more modifications than dimmer lights closer to the ground. The minimum mounting height for streetlights is usually 25 ft. At that height, 150 w HPS lamps are typically used. Table 7 assumes these minimum standards. However, reductions may be possible and should be considered, particularly with respect to lamp wattage.

Step 4. Consult with the lighting custodian and permitting authority (see Chapter 3, Page 17, *Altering Roadway Lighting Systems*) to determine if the mounting height and/or lamp size can be reduced. Go to the appropriate section of the table (*Is Lighting Configuration Adjustable?*) in response to that determination.

If the mounting height and/or lamp size can be reduced, light management objectives will be easier to achieve. It is assumed that in many urban settings, where traffic flow and pedestrian safety are of paramount concern, the mounting height and lamp size cannot be adjusted, because it would result in unacceptable

deviations from the photometric properties of the roadway lighting design. If adjustments are acceptable, select an alternative from the rural section of the table.

Step 5. Determine if the lamp is mounted within a drop globe or cutoff fixture and go to the appropriate section of the table.

Light from cutoff fixtures will be easier to manage than light from other styles of fixtures.

Step 6. Assess the linear extent and height of the dune and vegetative buffer between the light source and the beach, and select the option in the table that most closely characterizes the environmental setting at the site.

The better the vegetative buffer between the beach and the light, the better able you will be to implement an effective modification. Man-made barriers, such as buildings and artificial light screens, are just as effective as dune vegetation and should be considered in this step.

If light is visible over a broad section of beach from both near the dune and near the waterline, consider the dune buffer as *Poor*. If light is visible from only one or a few narrow sections of beach near the dune, consider the dune buffer as *Good*.

Step 7. Select the recommended modification that is most appropriate to your specific lighting problem.

Recommendations for effective light management are represented by numbers corresponding to **modifications listed in Table 7D** (Page 62). Several recommendations are provided for each lighting situation. Each recommendation is enclosed in parentheses. Some recommendations consist of only a single modification, while others involve a combination of modifications. The first of the listed recommendations is usually the simplest. The last of the listed recommendations is usually the most complicated and/or costly, but it is the one that has the highest probability of achieving light management objectives.

Example 1.

A 150W Cobrahead drop globe streetlight, mounted at a height of 25 feet, is located about 200 feet from the beach in an urban area, and there is a poor dune buffer between the light and the beach. The recommended modification from Table 7B (100-300 feet from the beach) is (7 & 2). This modification would consist of changing to a cutoff style fixture (7) and then applying a shield (2).

Example 2.

A 250W cutoff fixture, mounted at a height of 30 feet, is located about 80 feet from the beach in a rural setting, and a good dune buffer is present between the light and the beach. After consulting with the lighting custodian and permitting authority, it is determined that the light fixture and wattage can be changed. The recommended modification from Table 7C (within 100 feet from the beach) is (6 & 2 & 4). This modification would consist of reducing the mounting height and wattage (to 70-watts) of the light (6) and then applying a shield (2) and amber lens (4). If it was determined that the mounting height and wattage could not be changed, one of two recommendations are provided. One (5 & 2) involves adjusting the light distribution by changing the socket position of the lamp (5) and then applying a shield (2). The other (8 & 2) involves changing the fixture to one with a different style of internal reflector (8) and then applying a shield (2).

Table 7A - Light Fixture More Than 300 Feet From the Beach

| Type of Roadway and Usage | Mounting Height and Lamp Size | Is Lighting Configuration Adjustable? | Fixture Style | Extent of Vegetated Dune Buffer | Recommended Modification See Table 7D |
|--|-------------------------------|--|---------------|---------------------------------|--|
| Rural, No Sidewalks, Little Pedestrian Traffic | ≤ 25 ft ≤ 150 watts | No | Drop Globe | Good | (2) or (2 & 3) |
| | | | | Poor | (2 & 3) or (7) or (7 & 2) |
| | | | Cutoff | Good | (2) |
| | | | | Poor | (2) or (2 & 5) |
| | > 25 ft > 150 watts | Yes | Drop Globe | Good | (7) or (7 & 2) |
| | | | | Poor | (6 & 2) or (6 & 7) or (6 & 7 & 2) |
| | | | Cutoff | Good | (2) or (6 & 2) |
| | | | | Poor | (6 & 2) or (6 & 2 & 5) |
| | | No | Drop Globe | Good | (7 & 2) or (7 & 2 & 5) |
| | | | | Poor | (7 & 2 & 5) or (7 & 2 & 8) |
| | | | Cutoff | Good | (2) or (2 & 5) or (2 & 8) |
| | | | | Poor | (2 & 5) or (2 & 8) or (2 & 5) or (2 & 8) |
| Urban, Sidewalks Present, Heavy Pedestrian Traffic | ≤ 25 ft ≤ 150 watts | No | Drop Globe | Good | (2) |
| | | | | Poor | (7) or (7 & 2) |
| | | | Cutoff | Good | (2) |
| | | | | Poor | (2) or (2 & 5) |
| | > 25 ft > 150 watts | No is assumed (If yes; select an alternative from the rural section above) | Drop Globe | Good | (7 & 2) or (7 & 2 & 5) or (7 & 2 & 8) |
| | | | | Poor | (7 & 2 & 5) or (7 & 2 & 8) |
| | | | Cutoff | Good | (2 & 5) or (2 & 8) |
| | | | | Poor | (2 & 5) or (2 & 8) |

Table 7B - Light Fixture 100-300 Feet From the Beach

| Type of Roadway and Usage | Mounting Height and Lamp Size | Is Lighting Configuration Adjustable? | Fixture Style | Extent of Vegetated Dune Buffer | Recommended Modification See Table 7D | |
|--|----------------------------------|--|---------------|---------------------------------|---------------------------------------|----------------------------|
| Rural, No Sidewalks, Little Pedestrian Traffic | ≤ 25 ft ≤ 150 watts | No | Drop Globe | Good | (7) | |
| | | | | Poor | (7 & 2) or (7 & 2 & 5) or (7 & 2 & 8) | |
| | | | Cutoff | Good | (2) or (2 & 5) or (2 & 8) | |
| | | | | Poor | (2 & 5 & 4) or (2 & 8 & 4) | |
| | > 25 ft > 150 watts | Yes | Drop Globe | Good | (7 & 2 & 5) or (7 & 2 & 8) | |
| | | | | Poor | (6 & 7 & 2 & 5) or (6 & 7 & 2 & 8) | |
| | | | Cutoff | Good | (2 & 5) or (2 & 8) | |
| | | | | Poor | (6 & 2 & 5) or (6 & 2 & 8) | |
| | | | No | Drop Globe | Good | (7 & 2) |
| | | | | | Poor | (7 & 2 & 5) or (7 & 2 & 8) |
| | | | | Cutoff | Good | (2) |
| | | | | | Poor | (2 & 5) or (2 & 8) |
| Urban, Sidewalks Present, Heavy Pedestrian Traffic | ≤ 25 ft ≤ 150 watts | No | Drop Globe | Good | (2) | |
| | | | | Poor | (7 & 2) | |
| | | | Cutoff | Good | (2 & 4) | |
| | | | | Poor | (2 & 5 & 4) or (2 & 8 & 4) | |
| | > 25 ft > 150 watts | No is assumed (if yes; select an alternative from the rural section above) | Drop Globe | Good | (7 & 2 & 5) or (7 & 2 & 8) | |
| | | | | Poor | (7 & 2 & 5) or (7 & 2 & 8) | |
| | | | Cutoff | Good | (2) | |
| | | | | Poor | (2 & 5) or (2 & 8) | |

Table 7C - Light Fixture Within 100 of the Beach

| Type of Roadway and Usage | Mounting Height and Lamp Size | Is Lighting Configuration Adjustable? | Fixture Style | Extent of Vegetated Dune Buffer | Recommended Modification See Table 7D | |
|--|-------------------------------|---------------------------------------|---------------|---------------------------------|---------------------------------------|---|
| Rural, No Sidewalks, Little Pedestrian Traffic | ≤ 25 ft ≤ 150 watts | No | Drop Globe | Good | (7 & 2) | |
| | | | | Poor | (7 & 2 & 5) or (7 & 2 & 8) | |
| | | | Cutoff | Good | (2 & 4) | |
| | | | | Poor | (2 & 5 & 4) or (2 & 8 & 4) | |
| | > 25 ft > 150 watts | Yes | Drop Globe | Good | (6 & 7 & 2) | |
| | | | | Poor | (6 & 7 & 2 & 5) or (6 & 7 & 2 & 8) | |
| | | | | Cutoff | Good | (6 & 2) |
| | | | | | Poor | (6 & 2 & 5) or (6 & 2 & 8) |
| | | | No | Drop Globe | Good | (7 & 2 & 5) or (7 & 2 & 8) |
| | | | | | Poor | (7 & 2 & 5) or (7 & 2 & 8) or (7 & 2 & 10) or (7 & 2 & 11) or (1) |
| | | | | Cutoff | Good | (5 & 2) or (8 & 2) |
| | | | | | Poor | (2 & 5) or (2 & 8) or (2 & 11) or (2 & 10) or (1) |

**Table 7C - Light Fixture Within 100 of the Beach
(Continued)**

| Type of Roadway and Usage | Mounting Height and Lamp Size | Is Lighting Configuration Adjustable? | Fixture Style | Extent of Vegetated Dune Buffer | Recommended Modification See Table 7D |
|--|-------------------------------|--|---------------|---------------------------------|---|
| Urban, Sidewalks Present, Heavy Pedestrian Traffic | ≤ 25 ft ≤ 150 watts | No | Drop Globe | Good | (7 & 2) |
| | | | | Poor | (7 & 2 & 5) or (7 & 2 & 8) |
| | | | Cutoff | Good | (2 & 4) |
| | | | | Poor | (5 & 2 & 4) or (8 & 2 & 4) |
| | > 25 ft > 150 watts | No is assumed (if yes; select an alternative from the rural section above) | Drop Globe | Good | (7 & 2 & 5) or (7 & 2 & 8) |
| | | | | Poor | (7 & 2 & 5) or (7 & 2 & 8) or (7 & 2 & 10) or (7 & 11) or (1) or (9) |
| | | | Cutoff | Good | (5 & 2) or (8 & 2) |
| | | | | Poor | (2 & 5) or (2 & 8) or (2 & 10) or (1) or (11) or (9) |

Table 7D - List of Lighting Modifications for Use in Tables 7A-C.

The following list of alternative lighting modifications progresses from the easiest and least expensive to the most difficult and expensive. Go to the corresponding page number for more information about the alternative.

1. Turn the light off (Page 40).
2. Apply a shield to the seaward portion of the fixture (if allowable) (Page 41).
3. Adjust the light distribution by aiming the fixture down and/or away from the beach (Page 43).
4. Install an amber filtering lens (on 70-watt cutoff fixtures only) (Page 47).
5. Adjust the light distribution by changing the lamp socket position (Page 42).
6. Reduce the mounting height and/or wattage of the light (Page 43).
7. Change the fixture to a cutoff style fixture (Page 42).
8. Adjust the light distribution by changing the fixture to one with a different style of reflector (Page 42).
9. Install shielded LPS lighting (Page 47).
10. Install a vegetative or synthetic light barrier (Page 47).
11. Move the fixture behind a building or other structure to block its view from the beach (Page 46).

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APPENDIX A - TECHNICAL WORKING GROUP
Coastal Roadway Lighting Manual

APPENDIX A

1998 TECHNICAL WORKING GROUP Coastal Roadway Lighting Manual

| Participant | Company/Agency | Department/Title |
|--------------------|---------------------------|--|
| Florette Braun | FPL | Environmental Services |
| Dwight Whitaker | FPL | Customer Service |
| George Shambo | FPL | Lighting Support Services |
| Rusty Russillo | FPL | Commercial/Industrial |
| Joe McAdams | FPL | Lighting Support Services |
| Bob Ernest | EAI | TWG Coordinator |
| Robbin Trindell | FDEP | Bureau of Protected Species Management |
| Blair Witherington | FDEP | Florida Marine Research Institute |
| Sandy MacPherson | USFWS | National Sea Turtle Coordinator |
| Ginny Chewuk | FDOT | District Lighting Engineer |
| Ann Broadwell | FDOT | Environmental Specialist |
| Warren Halper | GE Lighting Systems, Inc. | Manager, Production Design |
| Richard Overman | City of Delray Beach | Chief of Police |

**APPENDIX A
(Continued)**

**2002 TECHNICAL WORKING GROUP *
Coastal Roadway Lighting Manual**

| Participant | Company /Agency | Department/Title | Address | Phone | Fax |
|--------------------|------------------------|--|--|------------------------|----------------|
| Florette Braun | FPL | Environmental Services | PO Box 14000 Juno Beach, FL 33408 | (561) 691-7059 | (561) 691-7070 |
| Scott Stephens | FPL | Distribution Product Engineering | 2455 Port West Blvd Building B2 West Palm Beach FL 33407 | (561) 845-4886 | (561) 845-4844 |
| Charlie Worsham | FPL | Lighting Services | 6001 Village Blvd West Palm Beach FL 33407 | (561) 640-2241 | (561) 640-2113 |
| Bob Ernest | EAI | TWG Coordinator | PO Box 405 Jensen Beach, FL 34958 | (772) 334-3729 | (772) 334-4925 |
| Robbin Trindell | FWC | Bureau of Protected Species Management | 3900 Commonwealth Blvd. Tallahassee, FL 32399-3000 | (850) 922-4330 | (850) 921-4369 |
| Blair Witherington | FWC | Florida Marine Research Institute | 9700 S. A1A Melbourne, FL 32951 | (321) 674-1801 | (321) 674-1804 |
| Sandy MacPherson | USFWS | National Sea Turtle Coordinator | 6620 Southpoint Dr., South Suite 310 Jacksonville, FL 32216 | (904) 232-2580 x110 | (904) 232-2404 |
| Ginny Dresser | FDOT | District Lighting Engineer | 719 S. Woodland Blvd. DeLand, Florida 32720 | (386) 943-5179 | (386) 736-5349 |
| Ann Broadwell | FDOT | Environmental Specialist | 3400 West Commercial Blvd. Ft. Lauderdale, FL 33309-3421 | (954) 777-4325 | (954) 777-4310 |
| Larry Schroeder | City of Delray Beach | Chief of Police | 300 W. Atlantic Ave. Delray Beach, FL 33444 | (561) 243-7851 | |

* Manual updates distributed to this group for comments and input in March 2002

APPENDIX B - 1998 STEERING COMMITTEE

Coastal Roadway Lighting Manual

APPENDIX B**1998 STEERING COMMITTEE
Coastal Roadway Lighting Manual**

| Participant | Municipality | Title | Department | Address | Phone | Fax |
|-------------------------|-------------------------|---|---|--|----------------|----------------|
| Mike Fayyaz | City of Fort Lauderdale | Project Engineer | Public Services Engineering Div. | 100 North Andrews Ave. Ft. Lauderdale, FL 33301 | (954) 761-5086 | (954) 761-5074 |
| Christopher W. Benjamin | St. Johns County | Intergovernmental Relations Coordinator | Administration | 4020 Lewis Speedway St. Augustine, FL 32095 | (904) 823-2508 | (904) 823-2507 |
| Dana Gourley | Sarasota County | Technical Coordinator | Natural Resources Department | PO Box 8 Sarasota, FL 34230 | (941) 378-6113 | (941) 378-6067 |
| John Walker | City of Delray Beach | Project Coordinator | Planning & Zoning | 100 NW 1 st Ave. Delray Beach, FL 33444 | (561) 243-7321 | (561) 243-7221 |
| Robert Walsh | Volusia County | Project Coordinator | Environmental Management Service Center | 123 W. Indiana Ave. DeLand, FL 32720-4621 | (386) 736-5927 | (386) 822-5727 |
| Robert T. Clapp | City of Hollywood | City Engineer | Development Administration/Engineering Div. | 2600 Hollywood Blvd., Room 308 Hollywood, FL 33020 | (954) 921-3254 | (954) 921-3481 |
| Charles Rose | City of Venice | City Engineer | Growth Management/Engineering | 401 W. Venice Ave. Venice, FL 34285 | (941) 485-3311 | (941) 484-8679 |

APPENDIX B

**1998 STEERING COMMITTEE
Coastal Roadway Lighting Manual**

| Participant | Municipality | Title | Department | Address | Phone | Fax |
|--------------------|-----------------------------|----------------------------------|------------------------------------|--|----------------|----------------|
| Randy Fowler | Town of Longboat Key | Acting Building Official | Planning, Zoning & Building Dept. | 501 Bay Isles Rd. Longboat Key, FL 34228 | (941) 316-1966 | (941) 316-1970 |
| Rocky Thompson | City of St. Augustine Beach | Commissioner | | 3701 A1A Beach Blvd. St. Augustine Beach, FL 32084 | (904) 471-2122 | (904) 471-4108 |
| Karen M. Collins | Manatee County | Director | Environmental Management | PO Box 1000 Bradenton, FL 34206-1000 | (941) 742-5980 | (941) 742-5996 |
| Paul Davis | Palm Beach County | Environmental Program Supervisor | Environmental Resources Management | 3323 Belvedere Road Building 502 West Palm Beach, Florida 33406-1548 | (561) 233-2434 | (561) 233-2414 |
| Earl King | City of Hallandale | Utilities Engineer | Public Works | 630 NW 2 nd Street Hallandale, FL 33009 | (954) 457-1621 | (954) 457-1624 |

**APPENDIX C - STATEMENT FROM USFWS
REGARDING GOOD FAITH EFFORTS TO RESOLVE
STREET LIGHTING PROBLEMS**



IN REPLY REFER TO:

United States Department of the Interior

FISH AND WILDLIFE SERVICE

6620 Southpoint Drive, South
Suite 310
Jacksonville, Florida 32216-0912

August 20, 1997

Mr. Robert G. Ernest
Ecological Associates, Inc.
P.O. Box 405
Jensen Beach, Florida 34958

Dear Bob:

This letter is in response to your August 1, 1997, telephone request for information on how the Service would proceed if sea turtle disorientations are attributed to lights corrected in a manner recommended in the coastal lighting management plan/manual being developed by the Technical Work Group convened by the Florida Power & Light Company.

As a member of the Technical Work Group, I foresee that only those recommendations that the U.S. Fish and Wildlife Service and Florida Department of Environmental Protection, which is also represented on the Technical Work Group, have approved will be included in the manual as roadway lighting problem solutions. Assuming this is the case and problem lights are corrected in the recommended manner, then I would anticipate that take of federally listed sea turtles would not occur as a result of those corrected lights. However, if take is attributed to the corrected lights, the Service would recognize that a good faith effort had been made and would continue to work with the party responsible for the lights to eliminate the take. Under these circumstances, the Service would not recommend prosecution under the Endangered Species Act as long as the responsible party continues to act in good faith to correct the problem.

I hope this information is helpful. Please contact me at 904/232-2580 (extension 110) if you have any questions or require additional information.

Sincerely,

Sandra L. MacPherson
Sea Turtle Recovery Coordinator

APPENDIX D - COST ESTIMATES FOR LIGHT MANAGEMENT OPTIONS

Cost Estimates for Light Management Options

These estimates are included to enable participants to evaluate the **relative** costs of various options. The numbers reflect general estimates for the type of work done by FPL during the year 2001. The actual cost to make these modifications at any particular location will vary on a case-by-case basis with the specifics of the location and equipment.

All situations will be priced on a case-by-case basis.

| Task | Price estimate per Light |
|---|-------------------------------------|
| Replace non-cutoff with cutoff | \$675* |
| Reposition head to redirect light | \$300 |
| Reduce the wattage | \$675* |
| Lower the mounting height | \$300 |
| Install/remove Autohaas 2422 amber filter lens (filters must be used in combination with other measures and can be used on 70W cobrahead cutoff <u>only</u>) | \$280* |
| Turn light off for nesting season | FREE to FPL customers as a courtesy |

* includes labor and materials

NOTE: It is advisable to consult with the responsible agencies to seek their agreement before making modifications.

APPENDIX E - GRANTS AND OTHER FUNDING SOURCES

Marine Turtle Grants

In February 1998, the Sea Turtle License Plate was offered for sale to motorists. Funds from this tag go to the Florida Fish and Wildlife Conservation Commission's Marine Turtle Protection Program.

A recent addition to this program is the Marine Turtle Grant Program. Money is available to coastal local governments, educational institutions and Florida-based nonprofit organizations for activities related to marine turtle protection. In 2001, \$156,276 was awarded to 14 organizations. There is approximately \$200,000 set aside for the grants in 2002.

Applications must be submitted in November for the following year. Activities that are eligible for funding include "the replacement or modification of existing lights near marine turtle nesting beaches". There are other activities that also qualify.

In 2001, Palm Beach County Department of Environmental Resources Management received \$25,000 for the production of educational material and to provide financial assistance to Palm Beach County's municipalities who wish to replace or modify artificial lights shining on the beach.

Apalachicola Bay & River Keeper, Inc received \$15,000 in 2001 to financially assist the residents of St. George Island in modifying or replacing lights that shine on the beach and also to apply window tinting. In addition, educational programs will be scheduled and property owners with problem lights will be notified by certified mail with an offer of assistance.

For more information on and an application for the Marine Turtle Grant go to <http://floridaconservation.org/psm/turtles/grantapp.htm>

Beach Renourishment Funds

Another source of funding is beach renourishment funds. Federal, state, and local governments support this funding program. Each year the Florida Department of Environmental Protection sends letters to local governments informing them of this program. There are several cities and counties in the state that currently have renourishment projects underway or scheduled. Manatee and Pinellas Counties both have projects where lighting modifications are part of the renourishment project.