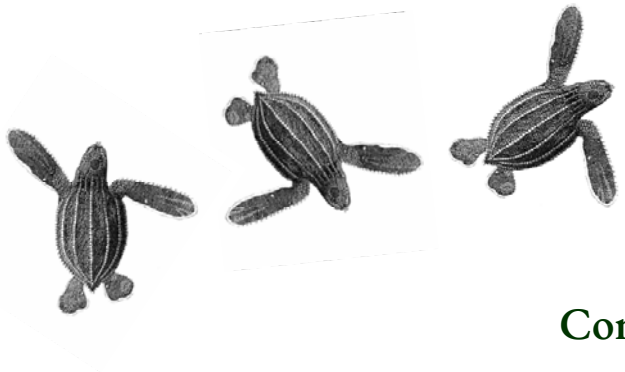
Reducing Light Pollution in a Tourism-Based Economy, with Recommendations for a National Lighting Ordinance



Prepared by the Wider Caribbean Sea Turtle Conservation Network (WIDECAST)

Kimberley N. Lake and Karen L. Eckert

WIDECAST Technical Report No. 11

2009

Cover photos: Tree-mounted double spotlights at the Frangipani Beach Resort, with new hotel construction in the background (photo by Kimberley Lake); Leatherback sea turtle hatchling attracted by beachfront lighting and unable to find the sea (photo by Sebastien Barrioz).

For bibliographic purposes, this publication should be cited as follows:

Lake, Kimberley N. and Karen L. Eckert. 2009. Reducing Light Pollution in a Tourism-Based Economy, with Recommendations for a National Lighting Ordinance. Prepared by the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) for the Department of Fisheries and Marine Resources, Government of Anguilla. WIDECAST Technical Report No. 11. Ballwin, Missouri. 65 pp.

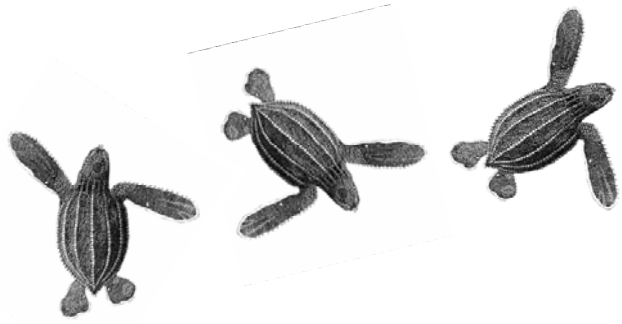
ISSN: 1930-3025

Copies of the publication may be obtained from:

Wider Caribbean Sea Turtle Conservation Network (WIDECAST)
1348 Rusticview Drive
Ballwin, Missouri 63011
Phone: + (314) 954-8571
Email: keckert@widecast.org

Online at www.widecast.org

Reducing Light Pollution in a Tourism-Based Economy, with Recommendations for a National Lighting Ordinance



Kimberley N. Lake
Karen L. Eckert

2009

WIDECAST
Wider Caribbean Sea Turtle Conservation Network

PREFACE AND INTENT

For more than two decades, the Wider Caribbean Sea Turtle Conservation Network (WIDECAST, www.widecast.org), with Country Coordinators in more than 40 Caribbean nations and territories, has linked scientists, conservationists, natural resource users and managers, policy-makers, industry groups, educators, and other stakeholders together in a collective effort to develop a unified management framework, and to promote a region-wide capacity to design and implement science-based sea turtle conservation programs.

As a Partner Organization of the UNEP Caribbean Environment Programme and its Regional Programme for Specially Protected Areas and Wildlife (SPAW), WIDECAST is designed to address research and management priorities at national and regional levels, both for sea turtles and for the habitats upon which they depend. We focus on bringing the best available science to bear on contemporary management and conservation issues, empowering stakeholders to make effective use of that science in the policy-making process, and providing an operational mechanism and a framework for cooperation within and among nations.

Network participants are committed to working collaboratively to develop their collective capacity to manage shared sea turtle populations. By bringing people together and encouraging inclusive management planning, WIDECAST is helping to ensure that utilization practices, whether consumptive or non-consumptive, do not undermine sea turtle survival in the long term. However, the recovery of remnant populations of Caribbean sea turtles will require more than a precautionary approach to sustainable use, it will also require thoughtful attention to both acute and chronic threats to important nesting and foraging habitats.

Anguilla is a small Eastern Caribbean island and, like so many other Caribbean islands, it plays host to seasonal nesting populations of endangered hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), and green (*Chelonia mydas*) sea turtles. While there is currently a moratorium on sea turtle capture, possession and sale, the Department of Fisheries and Marine Resources is concerned about the short- and long-term degradation and loss of nesting habitat to development-driven forces. Most of these factors relate to tourism pressures and include coastal construction, artificial beachfront lighting, and illegal beach sand mining. Artificial lighting near nesting beaches is well known to deter or disrupt the nesting sequence, and to inhibit sea-finding in post-nesting females and newborn hatchlings.

Based on stakeholder consultations and comprehensive lighting assessments conducted at selected tourism properties, this report provides recommendations for mitigating the negative effects of beachfront lighting on sea turtles, articulates principles for a broader policy-based solution, and develops the essential components of a national Lighting Ordinance, emphasizing safety, economy, enforceability, and flexibility in view of the wide variety of properties and lighting objectives along the coastline. It is our hope that participating resorts will take the recommendations to heart, that other hotels in Anguilla will take similar action to help reduce the impact the tourism industry has had on sea turtles nesting on the island, and that a Lighting Ordinance will soon become incorporated into the island's regulatory framework, setting a progressive example for other nations to follow.

Karen L. Eckert, Ph.D.
Executive Director
WIDECAST

ACKNOWLEDGEMENTS

The senior author thanks *Cuisinart Resort and Spa*, *Frangipani Beach Resort*, and *Covecastles* in Anguilla, British West Indies, for kindly providing access to their properties and to their professional staff. I would especially like to thank the Managers at these properties, each of whom was crucial to my understanding of the lights that serve so many essential purposes at these beautiful and unique destinations. Special thanks are extended to James Gumbs (Director of the Department of Fisheries and Marine Resources and WIDECAST Country Coordinator in Anguilla) and to Farah Mukhida (Anguilla National Trust), who personally escorted me during nighttime lighting assessments. Mr. Gumbs generously arranged, prior to my arrival, partnerships with the properties involved in this assessment, and he guided and encouraged my efforts throughout my stay in Anguilla (June-August 2007). I am grateful to the Fisheries Officers who made my time on the island so very enjoyable, allowed me to tag along on their many expeditions, and drove me about Anguilla in a 4-wheel drive vehicle. I am quite certain that, without them, I would not have had access to many of the beaches on the island, since my vehicle was less than able to deal with the terrain. I am also grateful to the summer interns who helped me to laugh at myself while I learned so much during my summer on-island.

My Advisor, Dr. Karen Eckert, was a wonderful mentor to me while I was enrolled in Duke University's graduate program. I want to thank her for having faith in my ability to complete this project successfully, and for ensuring my success by guiding me through the entire process. This WIDECAST Technical Report is based on the results of my Master's Project, completed for a Master of Environmental Management degree at Duke University. My training in lighting assessments I owe to John English Knowles (The Nature Conservancy) who, at his own expense, traveled to Florida to teach me the art of conducting formal lighting assessments (my project is based, in part, on a similar assessment he conducted in Barbados for his Master's Project at Duke University). He remained accessible to me while I prepared for my research and while I was working in Anguilla, and he kindly encouraged my efforts and reviewed results.

I sincerely thank my landlord in Anguilla, Mr. Rhon Connor (Department of Environment, Government of Anguilla) and his family, who made my transition into life in Anguilla as seamless as possible, provided excellent accommodations, hand-picked service providers to meet my needs while on the island, and maintained contact to provide support through the completion of my project. I am grateful for his friendship, guidance and kind words. I am also very grateful to Mr. Erik Martin (Ecological Associates, Inc.) for his thorough review of this report and its recommendations. Finally, I thank my loving family and friends in my native Trinidad, as well as in the United States, for supporting me with visits and phone calls while I was performing my research.

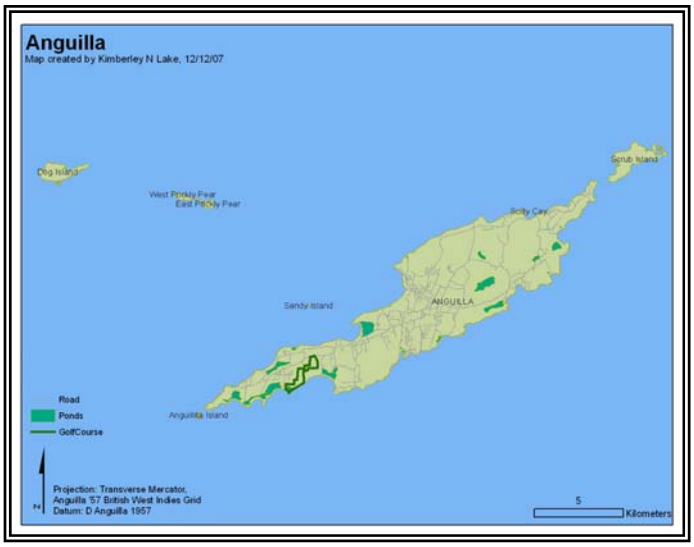
Essential financial support was provided by the Government of Anguilla, the Lazar Society of International Development and the David Brower Fund at Duke University, the Columbus Zoo, and the Wider Caribbean Sea Turtle Conservation Network (WIDECAST).

This research was performed under an appointment to the U.S. Department of Homeland Security (DHS) Scholarship and Fellowship Program, administered by the Oak Ridge Institute for Science and Education (ORISE) through an interagency agreement between the U.S. Department of Energy (DOE) and DHS. ORISE is managed by Oak Ridge Associated Universities (ORAU) under DOE contract number DE-AC05-06OR23100. Opinions expressed in this paper are the author's and do not necessarily reflect the policies and views of DHS, DOE, ORAU/ORISE, or Duke University.

TABLE OF CONTENTS

INTRODUCTION

Anguilla is the northernmost of the Leeward Islands of the Lesser Antilles in the eastern Caribbean Sea. The island is approximately 35 square miles in size, being 16 miles long and 3.5 miles across at its widest point (Encyclopædia Britannica, 2008), with a population of about 14,436 (CIA, 2009). In addition to the main island, the territory includes several small and uninhabited islets, including Dog Island, Prickly Pear Cays, Sandy Island, Seal Island, Sombrero Island, Scrub Island, Scilly Cay, and Anguillita.



Map of Anguilla (18°15′ N, 63°10′ W), located in the eastern Caribbean Sea. GIS Data courtesy of DFMR, Anguilla.

Anguilla is situated on the Anguilla Bank, which it shares with the island of Sint Maarten / Saint Martin (jointly administered by the Dutch and French Governments) and the French island of Saint Barthélémy. Politically, Anguilla is an internally self-governing Overseas Territory of the United Kingdom, having been established as a British dependent territory through the UK Anguilla Act of 1980. The UK is responsible for the island's external affairs (e.g., defense, international agreements), while internal affairs, including legislation and enforcement related to fisheries and the environment, are the responsibility of the Anguillan government (Godley et al., 2004; Bräutigam and Eckert, 2006).

Anguilla has few natural resources, most of which are directly linked to the ocean, and generally poor soils that are unsuitable for a wide range of agriculture. Tourism revenues are significant to the economy of the island. The tourism industry in Anguilla flourished in the 1980s and the 1990s, during which time the number of visitors increased more than seven-fold from 17,561 in 1982 to 125,780 in 1995 (Gell and Watson, 2000). In 2005, 143,186 visitors arrived in Anguilla, a 16% increase over 2004 arrivals (Anguilla Tourist Board, 2006).

The island's clientele tends to be elite, as described in travel magazines and other popular media (e.g., Yancey, 2008). Accommodations range from small guesthouses to large and exclusive hotels and villas. The tourism industry is the major catalyst for development on the island, and beachfront construction has degraded (such as through light pollution) or eliminated nesting habitat for endangered sea turtles (Godley et al., 2004).

Protecting important habitat is an essential step in the recovery of depleted sea turtle populations (e.g., Bell et al., 2007). Protecting critical life stages is also an important element of management. Frazer (1986) estimated that one egg in 1,000 results in an adult sea turtle; therefore, successful egg-laying and hatching, as well as protection of large juveniles and breeding-age adults (see Heppell et al., 1999, 2000, 2004), is important to increasing the population of nesting turtles on Anguilla. The odds that a hatchling will successfully reach the sea, however, can be compromised in the presence of artificial beachfront lighting (Witherington and Martin, 2003).

Hatchlings rely primarily on brightness cues to find their way to the ocean. Artificial lighting landward of the nesting beach can cause hatchlings to become confused and orient themselves inland instead of to the water, resulting in increased depredation by birds and mammals, or fatal dehydration and/or fatigue. Natural resource managers can respond to this threat by eliminating beachfront lighting, reducing the risk through mitigation measures, relocating eggs to lower lit areas, or doing nothing (Witherington, 1999).

"Doing nothing" in Anguilla is not a viable option for promoting sea turtle recovery. Coastal development on the island is expanding, meaning that major anthropogenic threats to nesting are unlikely to decrease over time. Large-scale relocation of eggs is also not an appropriate option for Anguilla. The risks associated with relocating nests could be counterproductive to Anguilla's conservation goals; for example, most beaches are not patrolled all night, meaning that eggs would mostly likely be exhumed and reburied the following day. The relocation of eggs 12 hours or more after a nesting event has been shown to reduce hatching success by up to 67% (Limpus et al., 1979). Because sand mining is also a serious threat to sea turtle nesting habitat, and it occurs on some of Anguilla's most remote beaches, simply relocating eggs to remote areas (i.e., away from artificial lighting) may not increase the probability of a successful hatch. Moreover, "remote" beaches are fast disappearing as exclusivity and privacy draw developers and tourists to secluded parts of the island. Even small-scale developments in these natural areas can quickly affect the nesting success of sea turtles. Captain's Bay, for example, a remote and important sea turtle nesting beach on the eastern end of the island, is currently occupied by one villa; however, the floodlights on this one property are bright enough to illuminate the entire beach at night (Kimberley Lake, personal observation).

Eliminating, or at least minimizing, the impacts of anthropogenic lighting is likely to be the most practical long-term option to increasing nest success and meeting conservation targets in Anguilla. With this in mind, the Department of Fisheries and Marine Resources requested the assistance of the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) in performing a comprehensive assessment of the major threats to sea turtle habitat from coastal development, with a special focus on light pollution, and developing a national Lighting Ordinance that met international best practices.

A green turtle hatchling orients successfully to the sea. Photo by Turtugaruba Foundation, Aruba.
** All photos were taken by the senior author, unless otherwise noted.*

Based on a series of stakeholder consultations and comprehensive lighting assessments (which were conducted at selected tourism properties, see Appendices), this report provides recommendations for a national Lighting Ordinance designed to reduce the impact of the tourism industry on sea turtles and their nesting habitats in Anguilla.

The draft Lighting Ordinance emphasizes safety, economy, flexibility, and enforceability in view of the wide variety of properties and lighting objectives along the coastline. It is our hope that a Lighting Ordinance will become incorporated into island regulations, setting a progressive example for other nations to follow.

SEA TURTLE MANAGEMENT IN ANGUILLA

Overview

Sea turtles have provided nutrition, wealth and in other ways been useful to Caribbean cultures for more than 2,500 years (e.g., Versteeg et al., 1990; Petersen, 1997; Frazier, 2003). Similarly, archaeological records in Anguilla confirm more than 1,000 years of sea turtle use for food, domestic tools, and utilitarian items (Peterson and Crock, 2001).

Hawksbill sea turtle in a Caribbean coral reef. Photo by Caroline Rogers (USGS).

Four sea turtle species are recorded in Anguilla; three of them lay eggs on the island's sandy beaches. The most abundant of these is the reef-dwelling hawksbill (*Eretmochelys imbricata*), which is present in nearshore waters year-round and comes ashore to nest from June to September (peak: July and August). Hawksbills rely for nesting on 19 of the island's 35 sandy beaches (Dow et al., 2007), the most important of these are Captain's Bay, Savannah Bay, Limestone Bay and Blackgarden Bay.

Green sea turtle in a seagrass foraging area. Photo by Caroline Rogers (USGS).

The herbivorous green turtle (*Chelonia mydas*) is also present year-around. Nesting is seasonal (May to September) and occurs primarily at Captain's Bay. In contrast, leatherback turtles (*Dermochelys coriacea*) are not resident, but arrive seasonally (March to July) from high seas foraging grounds to lay their eggs mainly along the island's northern coast (Dow et al., 2007).

Peak nesting season does not coincide with peak tourist visitation, but the need for lighting associated with tourism development is year-round. Fewer tourists does not necessarily lead to lower lighting; for example, beachfront bars and other outdoor property and security lighting are often fully operational throughout the year.

Leatherback sea turtle on the nesting beach. Photo by Scott Eckert (WIDECAST).

National Legislation

According to Bräutigam and Eckert (2006), the exploitation of sea turtles in Anguilla has been regulated since 1948 when the Turtle Ordinance Cap. 99 established a four-month closed season on the take of turtles and eggs, and a minimum size limit (20 lb) for all species. These same provisions were incorporated into subsequent regulations, the most recent being the Fisheries Protection Regulations of 1988, issued under the Fisheries Protection Ordinance No. 4 of 1986.

In 1995, the Fisheries Protection Regulations of 1988 were amended to close the open season entirely, bringing into effect a moratorium on the capture of turtles and take of eggs for a period of five years. The amended Regulations also placed an indefinite ban on the use of gill nets, thereby reducing the risk of incidental take in fishery operations. The moratorium has since been renewed twice, and is currently scheduled to expire in 2020 (Bräutigam and Eckert, 2006).

The moratorium addresses direct take, but is not designed to safeguard critical nesting or foraging habitats. The recovery of nesting populations in Anguilla is, therefore, still in jeopardy from habitat degradation and loss, especially of nesting beaches and largely due to construction and related activity (e.g., illegal sand mining) associated with coastal development along the island's 38 miles of coastline.

The Department of Fisheries and Marine Resources (DFMR), created in 1991, is responsible for the improvement and management of fisheries and marine parks within a Territorial Sea (extending 12 nm from shore), including all issues associated with coastal zone management. The DFMR is also responsible for enforcing fisheries legislation within the Territorial Sea and an approximately 33,000 square mile Exclusive Fisheries Zone, which extends 200 nm from shore.

A symmetrical crawl emerging from the sea is one clue that a green sea turtle has nested on Katouche Bay, Anguilla.

DFMR staff tagging a hawksbill sea turtle in Anguilla.

Also relevant is the Marine Parks Act of 1982 and Regulations of 1993, which provide for the designation of "any portion of the marine areas of Anguilla" as a marine park to protect fish and fauna, preserve and enhance natural beauty, promote public enjoyment, and facilitate scientific research, and the Beach Protection Act, which protects listed beaches from sand and gravel extraction within 200 feet of the foreshore and establishes penalties for violations. The Beach Protection Orders, Revised Regulations of Anguilla B25-1, designates 18 beaches as protected (Bräutigam and Eckert, 2006).

Despite staff and budgetary constraints, DFMR collects information on the distribution and abundance of sea turtle nesting, often with the help of local residents and hotel staff, and supports an active population sampling and census program at selected foraging sites (Godley et al., 2004). Regarding enforcement, DFMR officers can press charges against offenders but they do not have the authority to make an arrest. Special marine police, or, in their absence, regular police officers, have the legal authority to apprehend offenders.

INTERNATIONAL AGREEMENTS

Because Anguilla is an Overseas Territory of the UK, the island cannot participate in international treaties to which the UK is not a Party. However, even if the UK participates in a treaty, Anguilla's membership is not automatic. Of the treaties relevant to sea turtle conservation to which the UK is a Party, Anguilla only participates in the Convention on Wetlands of International Importance (Ramsar Convention on Wetlands, http://www.ramsar.org/) and the World Heritage Convention (http://whc.unesco.org/) (Bräutigam and Eckert, 2006). The Ramsar Convention has 158 Parties and focuses on the wise use of wetlands and their resources, while the World Heritage Convention has 170 Parties and focuses on the preservation of sites of major cultural importance.

Educational brochures about ratifying multilateral agreements, distributed by the Anguilla National Trust and the Department of Environment, Government of Anguilla.

There are four multilateral agreements to which Anguilla is *not* Party that could contribute significantly to sea turtle conservation efforts. Two have been signed by the UK, but do not extend to Anguilla:

The first of these is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, http://www.cites.org/), ratified by the UK in 1975. Under CITES, international trade in certain species, including sea turtles, is strictly regulated.

The second of these is the Convention on Migratory Species (CMS or Bonn Convention, http://www.cms.int/), ratified by the UK in 1985. The Convention calls for, among other things, strict monitoring of listed species, multi-party conservation and management planning, and cooperative research.

The Protocol Concerning Specially Protected Areas and Wildlife (SPAW Protocol) to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention, http://www.cep.unep.org/cartagena-convention), has been signed but not ratified by the UK. Parties to this Protocol are required "to ensure the protection and recovery of endangered and threatened species" (art. 11) listed in the Protocol's annexes, including six species of sea turtle. Parties are also encouraged to "take the necessary measures to protect, preserve and manage in a sustainable way … areas that require protection to safeguard their special value", including habitat critical to the survival of endangered species (art. 3). Ratification of SPAW by the UK – and its extension to the Overseas Territories – depends on the Overseas Territories having supporting national legislation in place.

The Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC, http://www.iacseaturtle.org/English/home.asp) is the only international treaty focused exclusively on sea turtles, and it articulates protection and conservation goals both on land (nesting beaches) and at sea (foraging grounds, migratory routes). It entered into force in 2001, but has been neither signed nor ratified by the UK and therefore does not apply to Anguilla or to any other Overseas Territory of the UK.

THREATS TO SEA TURTLES IN ANGUILLA

The dependence of both industry and recreation on the coastal resources of Anguilla is obvious. However, not all coastal zone development and/or activity poses a direct threat to sea turtle nesting on the island. The most serious threats include artificial lighting along the coastline, generally associated with physical development directly (or nearly so) on the beach platform; illegal sand mining; and the poaching of turtles and their eggs.

New hotel construction on the coast of Anguilla.

With sea turtle survival rates naturally low and Anguilla's sea turtle population having been heavily exploited (Godley et al., 2004), minimizing adverse threats is critical to the recovery of remnant sea turtle stocks.

ARTIFICIAL LIGHTING

Maunday's Bay, lit by the outdoor and restaurant lighting of Cap Juluca Resort in Anguilla. Beach driving can also reduce hatch success by crushing eggs buried beneath the sand.

Reduced success among sea turtle hatchlings attempting to locate the sea in the presence of beachfront lighting, and the reduced attractiveness of brightly lit beaches to egg-bearing females, are well documented. For an extensive review of research done on the effects of lighting and human activity on nesting behavior and hatchling emergence, please refer to Witherington and Martin (2003).

Adult females seeking to lay their eggs preferentially crawl onto darker sections of sandy beach, as opposed to well lit areas (Witherington, 1992; Salmon, 2003). The female may also be startled by human activity or lights after she has begun the nesting sequence, and this can sometimes result in her abandoning the effort altogether (resulting in a "false crawl", or a beaching that does not result in the laying of eggs).

It is generally assumed that sea turtles choose nesting sites based on favorable conditions for safe nesting and the production of fit offspring. Because females can be deterred by light pollution from approaching preferred nesting beaches, they are sometimes forced into sub-

optimal nesting habitat where the number of hatchlings produced and their survivorship may be reduced and where hatchling sex ratios may also be affected. Finally, there is the potential that sea turtles deterred from nesting may shed their eggs at sea (Witherington and Martin, 2003).

The adverse effects of artificial lighting on the ability of sea turtle hatchlings to reach the ocean are also well known (e.g., McFarlane, 1963; Witherington et al., 1990; Witherington, 1991; Witherington and Bjorndal 1991a,b; Salmon et al., 1995b; Tuxbury and Salmon, 2005). Emerging hatchlings align themselves with the brightest ambient cues (often described as the lowest, brightest horizon), which, on a pristine beach, are associated with the open horizon and reflective surface of the water, as opposed to the landward vegetation or dune line. The journey to the water must take place quickly or the hatchling may become tired, dehydrated, and an easy meal for predators.

On a lit beach, hatchlings can become disoriented and confused, crawling inland toward artificial light sources instead of to the water. One hotel manager in Anguilla recounted to the author his personal experience in watching a sea turtle nest hatch, and described how the hatchlings would immediately align themselves to even brief flashes of light, such as from a camera (Rupert Balgobin, Head Engineer, Cuisinart Resort and Spa, personal communication).

Anguillan beaches are often well lit, as sandy beaches are among the most attractive sites for tourism-oriented businesses, including restaurants and hotels. Among the beaches observed by the author to have the most significant light pollution are Captain's Bay, Maunday's Bay, Mead's Bay, Shoal Bay East, Barnes Bay, and, to a lesser extent, Rendezvous Bay. Notwithstanding, all developed beaches on the island are potentially threatened by light pollution.

Illegal Sand Mining

Sand extraction from beaches and dunes for construction purposes is a major cause of erosion, as mining often removes sand at higher rates than natural processes can replace it (e.g., Cambers, 1997). Over time this activity renders beaches unsuitable for sea turtle nesting, and the loss of these important habitats can undermine other conservation efforts.

Although there are legal quarrying sites, illegal sand mining provides a nearly free source of raw materials. Law enforcement is inadequate to the task, and sand poachers have seriously damaged the island's nesting beaches. Heavily mined sites, such as Sile Bay and Meads Bay, were especially vulnerable to the waves of Hurricane Luis. Sile Bay, once an important nesting beach, is now a wasteland of gravel and rock. Other beaches under immediate threat include Windward Point, also an important nesting site. Sand mining is now prohibited on all beaches and dunes except at Windward Point (UNESCO-CSI, 1997).

Poaching

While there are no official statistics, and there seems to be a general understanding among island residents of the importance of eggs to population recovery, turtles and their eggs are traditional fare and it is not unheard of that someone who happens upon a nest would "take a few eggs home" (personal communication, Katouche Bay resident). There are differing local perspectives and responses to this reality – some residents believe that poaching is active and territorial (with poachers regularly patrolling claimed zones), others contend that it is "a thing of the past" and that most people, while they might joke about taking eggs, would not actually remove them from the nest (personal communication, security guard, Mallihouana Hotel).

LIGHTING ASSESSMENT METHODOLGY

To address the threat posed by artificial beachfront lighting, formal assessments were undertaken at three tourism properties, located on active sea turtle nesting beaches, between 21 June 2007 and 21 August 2007. The main objectives were to provide residents and property managers with best management practices for reducing the potentially negative effects of artificial lighting on sea turtles and their young, and to make recommendations to Government concerning a national Lighting Ordinance, to be incorporated into island regulations, that would allow for greater protection of sea turtles on nesting beaches (Lake, 2008).

The Assessor documenting beachfront lighting on Mead's Bay, Anguilla, during the summer of 2007.

To achieve these objectives, the Assessor (Kimberley Lake) convened, in partnership with local authorities, stakeholder meetings including Government officials and the private sector (e.g., fishers, property managers, members of the Anguillan Hotel and Tourism Association).

Stakeholder-led processes are important in the formulation of new policy – not only to encourage a sense of ownership, but also to promote the most effective and site-appropriate long-term results (McNeely, 1995; Margoluis and Salafshy, 1998; Marcovaldi et al., 1999).

The Assessor then visited active sea turtle nesting beaches and ranked each beach based on: the extent to which lighting regimes associated with proximal development had the potential to negatively affect the selection of that beach (by an egg-bearing sea turtle) for nesting, the Assessor's perception of the degree to which a sea turtle was likely to survive the nesting process (e.g., without being disoriented inland, away from the sea), and, similarly, the likelihood that hatchlings would successfully orient to the sea.

This evaluation was largely qualitative. Without complete historical data documenting sea turtle nesting, it was difficult to determine the exact nature of any potential threat posed to sea turtle nesting success by the built environment. The evaluation was largely based on empirical observation, literature reviews, informal interviews with local residents, and the Assessor's knowledge of the potential effects of various human activities on sea turtle nesting and hatchling survival. The island-wide evaluation provided the Assessor with a greater understanding of the larger context of development in Anguilla, and set the stage for in-depth lighting assessments conducted at three beachfront properties.

The in-depth lighting assessments were undertaken in close collaboration with hotel staff and/or property managers and were conducted at three sites – Cuisinart Resort and Spa (see Appendix B), Frangipani Beach Resort (see Appendix C), and Covecastles (see Appendix D) – where sea turtle nesting was known to occur. In each case, a comprehensive Lighting Assessment Report was drafted, reviewed, and finalized with input from local partners.

At each of the three sites, light sources were identified and ranked during daytime and nighttime lighting inspections conducted by the Assessor in collaboration with property managers and staff. Such cooperation is essential, because property managers have unique and intimate knowledge of the purpose and timing of each light source on the property. They also know which lights are under the control of the property, which are controlled by the guests, and which are controlled by municipal authorities. By collaborating directly with managers and owners from the start, they become directly involved in both the assessment and its recommendations – increasing the likelihood that the negative effects of property lighting can be mitigated in ways that are both cost-effective and site-appropriate.

A daytime inspection performed by John English Knowles in Barbados. Photo by Karen Eckert (WIDECAST).

Daytime inspections identified all potential sources of beach lighting, while nighttime inspections confirmed which of these sources might jeopardize the integrity of nesting habitat and/or the success of nesting and hatching sea turtles. By performing nighttime inspections at different times, the Assessor was able to observe the impacts of each type of light during the normal transition from daytime to nighttime lighting at these three properties, information that strengthened the Lighting Assessment Reports presented to managers (see Appendices B, C, D).

Whether day or night, the process of ranking was based on that outlined by John English Knowles' (2007) assessment of beachfront lighting in Barbados. He outlined a ranking system where a rank of '1' describes indirect light visible by an observer on the beach, but not likely to present a strong attraction to nesting or hatching turtles, and a rank of '2' describes direct light or a visible globe, glowing element, lamp, or reflector likely to disorient turtles. He noted the neither '1' nor '2' ranked lights were strong enough to cast a discernible shadow on the beach during a dark night. In contrast, a rank of '3' describes a light source strong enough to cast a shadow on the beach regardless of the illumination being direct or indirect.

Ideally, a beach should not be subjected to artificial lighting at all. In that case a score of zero ('0') would confirm that there is no need for mitigation measures. However, the ideal scenario may not be attainable on a developed beach and, in that case, a rank of '1' is preferred over a rank of '2', which is preferred over a rank of '3' (Knowles, 2007).

By becoming involved in a formalized assessment of this type, hoteliers and property owners/managers create a baseline against which to evaluate the success (or failure) of changes made in an attempt to reduce the threat posed to sea turtles nesting on beaches nearby.

An endangered leatherback sea turtle hatchling orients to a bright onshore light, ... and away from the sea. Photo by Sebastien Barrioz.

COASTAL LIGHTING IN ANGUILLA

On an island like Anguilla, with high levels of coastal tourism and development and where beaches cannot feasibly be dark and quiet year-round, it is vital that the owners and managers of coastal properties be committed to creative lighting practices that minimize impacts on proximal sandy beaches.

Anguilla's coastal properties are mainly touristic; however, within this category there is variation in property size, type, and management. Accommodation is available in a number of configurations, including "full-fledged and mini-resorts, hotels and apartment hotels; private and club-style villas, apartments and condos; small inns and guest-houses" (Ministry of Economic Development, 2005).

According to the Anguilla Accommodation Rate Guide, there are 11 hotels, nine apartments, villas and condominium developments, and eight inns and guesthouses on the island (Government of Anguilla, 2005). Each property type faces a different suite of challenges when it comes to light management. The properties profiled in this report were selected, in part, to represent this diversity.

LARGE HOTELS

Anguilla's tourism industry serves a range of clientele, but leans mostly toward the elite. There are several large and spectacular hotel properties in Anguilla, most of which occupy the western end of the island. These large hotel properties are often characterized by off-island ownership, with design decisions made to suit corporate guidelines that present consistency to travelers, regardless of whether they visit Anguilla or Antwerp.

Cuisinart Resort and Spa on Rendezvous Bay, Anguilla.

Featured Property: Cuisinart Resort and Spa

The Cuisinart Resort and Spa, the focus of one of the Lighting Assessments[1], is a 5-star resort boasting Grecian-style architecture and constructed over much of the Rendezvous Bay coastline.

The 93-room property has its own hydroponic farms and organic gardens where vegetables and other produce are sourced for meals offered by on-site restaurants. The least expensive room at this property advertises at US$ 400 per night in the low season, rising to more than US$ 5,000 per night during peak visitation.[2]

[1] See Appendix B for a comprehensive Lighting Assessment Report and recommendations.
[2] http://www.cuisinartresort.com/; Accessed 1/16/2008

Mitigating Beachfront Lighting in Large Hotels

One benefit to mitigating light pollution at a large hotel, and especially if the property is affiliated as part of a successful regional or global chain of hotels, is that there may be greater financial resources available, suggesting that on-site changes to lighting regimes might be made relatively quickly. In addition, these properties may have larger advertising budgets than would a smaller hotel, suggesting that the hotel could advertise their 'green' decisions more broadly and possibly capitalize more quickly on lighting mitigation investments.

Notwithstanding these potential benefits, several challenges may face managers wishing to mitigate the effects of large hotels' lighting on nesting beaches. Ownership by foreign companies can mean less flexibility with mitigation options, especially if these relate to design elements. For example, changing the type of light fixture may depend on whether the new style blends with the image of the hotel – and whether similar fixtures are available to properties in other areas, since consistency is valued. Similarly, recommending increased use of foliage and natural vegetation to shield lighting from the nesting beach can be problematic if foliage type, density and/or height is already established as part of a company-wide image protocol.

The perception of safety and security is an important issue at every property. But the special challenge for a chain hotel is that a mishap at one venue can tarnish the reputation of the entire chain, potentially making guests less willing to stay at other properties controlled by the same management. While research has shown that bright lights and increased security are not necessarily correlated, and that the benefits of excessive lighting are largely psychological (e.g., Ramsay and Newton, 1991), the event of an attack against a guest on a lower-lit beach might lead the public to perceive that the incident could have been prevented by more lighting.

Frangipani Beach Resort on Mead's Bay, Anguilla.

SMALL HOTELS

Smaller hotels, local- and foreign-owned, are well represented in Anguilla.

Featured Property: Frangipani Beach Resort

The Frangipani Beach Resort is a small, intimate property on Meads Bay.[3] A restaurant with an outdoor dining space offers a view of the sea and is one of the property's most striking features. The hotel offers eight recently renovated and well appointed condominium-style suites with private balconies and modern entertainment systems. The least expensive accommodation advertises at US$ 250 per night (low season), rising to $450 during peak season. The Penthouse Suite is the most expensive, as much as $2,400 per night during peak tourist season.[4]

[3] See Appendix C for a comprehensive Lighting Assessment Report and recommendations.
[4] http://www.frangipaniresort.com/rates.php, Accessed 1/23/2008

Mitigating Beachfront Lighting in Small Hotels

Smaller properties, especially locally owned, have some advantages with regards to beachfront lighting mitigation. Managers are likely to have more control and potentially more flexibility with the "look and feel" of the property, and this is especially true if the hotel is not part of a themed or branded chain of properties. Smaller hotels can also capitalize on the image of intimacy and seclusion with lower intensity lighting on the property. Notwithstanding, making large changes to lighting infrastructure could be challenging for smaller hotels and their (presumed to be smaller) budgets. In addition, the sentiment is sometimes voiced that removing lighting from the property, especially at night, makes a smaller property appear too desolate and remote.

TIMESHARE AND MANAGED PROPERTIES

Another type of property in Anguilla is the privately owned but externally managed "timeshare". The constituent rental units tend to be designed by the same architect, and the resulting uniformity can be reminiscent of a resort or large hotel property. While the property may have several units available for rent, some proportion of units are likely to have been built to the specifications of individual and almost exclusively foreign owners. When the owner is ready to return to Anguilla, often on a seasonal visitation schedule, the unit is appointed to the specifications of the client. For the bulk of the year, however, the units are either left empty or rented to others, depending on the wishes of the owner. In this scenario the management company may have considerable discretion in managing the beachfront and other grounds, including lighting.

Featured Property: Covecastles

Covecastles is an example of a managed property in Anguilla[5]. This exclusive development is located on Shoal Bay West, a long and secluded stretch of beach on the western end of the island. With seclusion comes the security of motion sensors and guards that respond discreetly to any alert. Native foliage on the beachfront side of the property effectively screens much of the light from occupied villas. There are no permanent structures or seating on the beach. Walking along this beach at night, guests enjoy the feeling of being the only person on the whole of Anguilla.

Covecastles, a managed property featuring a series of luxury villas on Shoal Bay East, Anguilla.

Two-bedroom villas are advertised for as little as US$ 600 per night in the low season[6], but prices rise fairly rapidly based on unit size and time of year. For one of the larger and/or better appointed units, guests pay nearly $6,400 per night during peak season.

[5] See Appendix D for a comprehensive Lighting Assessment Report and recommendations.
[6] http://www.covecastles.com/rates.html, Accessed 1/23/2008

Mitigating Beachfront Lighting in Managed Properties

Foliage planted between the villas and the nesting beach effectively blocks light emitted from the development at Covecastles in Anguilla.

There are clear advantages to managing lighting on a property such as Covecastles. For example, a generally wealthy clientele tends to value seclusion and may be more willing to shun a well-lit beach. Dense foliage and dark beaches are symptomatic of the expressed desire of an elite group of guests who want to feel like the only people on the island. As a result, the adjoining nesting beach is less affected by light pollution than might be expected on a property of this size. Research supports the conclusion that light pollution can be effectively reduced through the use of landscaping (e.g., Salmon et al., 1995a,b), confirming that creative designs can benefit both property owners and native wildlife.

Another advantage of managed property is that units are typically highly individualized and are managed as such. Local issues, including maintenance and grounds, are dealt with by appointed managers with considerable authority to, for example, implement "sea turtle friendly" lighting regimes, especially when villas are unoccupied or owners are off-island.

Drawbacks to lighting mitigation schemes at managed properties are associated with the special needs and privileges of high-paying guests: at more than $6,000 a night, "what the client wants, the client gets". This can be a problem if clients reject initiatives to alter lighting regimes for the benefit of sea turtles.

Another potential problem is similar to that of large hotels; namely, structure and design. These grand properties are celebrated for unique architectural design and detail. Lighting is a design component, and change can be difficult. The solution is to work in close collaboration with individual owners and managers toward shared goals.

Private house on Limestone Bay, Anguilla, with the construction of a new house in the background.

HOUSES AND VILLAS

The number of private properties on the shoreline is increasing in Anguilla. Moreover, these properties are often large and seasonally unoccupied. Although there are coastal zone ordinances in place that mandate building setbacks, enforcement is weak. The

result is a growing trend in the number of nesting beaches negatively affected by lighting associated with houses and villas.

Mitigating Beachfront Lighting in Personal Properties

As with other types of properties, there are advantages and disadvantages to working with private homeowners to mitigate light pollution. Among the potential advantages are that homeowners tend to be wealthy, suggesting that the cost of mitigation (e.g., altering existing lighting regimes) might be less of an issue. In addition, because homes are individually owned, there are no corporate constraints related to architecture or design, and thus perhaps more flexibility in finding lighting fixtures that both appeal to the homeowner and reduce the negative effects of beachfront lighting. Disadvantages include lack of access to absentee owners. In addition, unlike a commercial property that can possibly exploit "sea turtle friendly" lighting as a marketing tool, private owners may have no real incentive to mitigate lighting other than a personal commitment to conservation or a desire to reduce energy use and/or operating costs.

Restaurant on Shoal Bay East, Anguilla.

RESTAURANTS

Anguilla's dining scene offers visitors a wide choice of dining ambiance and cuisine specialties. Visitors can select from among more than 70 restaurants, choosing a dining experience "based on an appetite impulse, a desire for a romantic or convivial setting, or their pocketbook." Cuisine specialties include Caribbean, Mediterranean, French, American, Creole, Continental, Italian, and Indo-Chinese (Ministry of Economic Development, 2005).

The diversity of ownership and clientele in the island's tourism industry is reflected in the range of restaurant types, locations, and price ranges. Some restaurants are free-standing, others are attached to hotels; some are locally owned, some foreign-owned; some are situated directly on sea turtle nesting beaches, others are not. Beachfront restaurants serve a variety of clientele, and many are open year-round. Because restaurants are typically open during nighttime hours, they present a special challenge for lighting.

Mitigating Beachfront Lighting in Restaurants

Among the most effective mitigation schemes for beachfront restaurants are the following: emphasize an intimate setting using table lamps (restricting light to the immediate area it is intended to serve), utilize ornamental plantings to block light, and/or incorporate sconces and light shades that both reduce beachfront lighting and enhance the restaurant's décor. Equally important is to work with management to ensure that lights that can be seen from the nesting beach are turned off when the restaurant is closed and lights that must remain on emit long wavelengths (e.g., low-pressure sodium vapor fixtures) less attractive to sea turtles. Cost savings should be emphasized. Potential obstacles to effective mitigation, especially in "wave-

view" restaurants, are architectural constraints and a stylistic commitment to an open air, ocean view, "sand in toes" ambiance in Caribbean beachfront dining.

PRINCIPLES FOR A POLICY-BASED SOLUTION

Several factors are important when considering policy-based solutions to beachfront lighting in tourism-based economies. Effective policies must embrace the needs – real and perceived – of stakeholders, including government agencies, property owners and managers, residents, and paying guests.

Shoal Bay East, Anguilla, lit by beachfront restaurants at night, yet the restaurants are closed.

With this in mind, a national Lighting Ordinance should satisfy at least the following five (5) criteria:

Increase Nesting Beach Quality – This is in line with the conservation aims of the DFMR, as well as other local entities, such as the Anguilla National Trust. Making beaches more suitable for egg-laying is an important step in increasing and safeguarding habitat that is necessary for the sustained recovery of nesting populations. This is a threshold criterion, meaning that any policy must satisfy this criterion.

Pictures of a hatching event at Gwen's Reggae Grille, Shoal Bay East, Anguilla.

Maximize Cost-Effectiveness – This criterion must take into account that two stakeholders ultimately bear the primary cost of mitigation; i.e., DFMR and property owners. DFMR has a large mandate and a limited budget. Therefore, costs associated with the policy, including implementation and enforcement, should be carefully balanced with expected gains. Property owners also face costs, including staff time and the material costs of implementing recommended changes to lighting regimes. Less quantifiable "costs" may include a perceived loss of aesthetic appeal associated with reduced or altered light.

Maximize Safety and Security – While there is debate about whether ambient lighting makes a location more or less prone to crime (e.g., Ramsay and Newton 1991), people tend to feel safer in well lit areas. Because some beachfront lighting is necessary for illuminating paths, stairways and entrances, it is imperative that the safety of guests and other facility users is not jeopardized by changes in lighting.

Maximize Enforceability – The potential to positively affect the quality of sea turtle habitat as a result of any mitigation mandated by a Lighting Ordinance, hinges on enforcement. Without

a proper enforcement strategy, the policy cannot achieve its objectives. Therefore the policy must take into account the size and capacity of the DFMR staff and budget, and/or provide for other enforcement options and/or authorities. Similarly, the Ordinance should embrace incentives designed to strongly encourage stakeholder buy-in, thereby reducing the need for law enforcement.

Ensure Flexibility to Adapt to New Scientific Information – The sea turtle moratorium was enacted, in part, to provide DFMR with an opportunity to collect data suitable for determining population trends, patterns of habitat use, etc. at the nation's nesting beaches and foraging areas. Updated information on the ecology and life history of local and regional sea turtle populations will be useful in evaluating the effectiveness of conservation efforts. The Lighting Ordinance should be flexible enough to allow for adjustments based on new scientific information.

DFMR staff measuring a juvenile green turtle (Scrub Island, Anguilla), caught as part of an ongoing research project.

BASIC COMPONENTS OF A LIGHTING ORDINANCE

A Lighting Ordinance can be a useful conservation tool if fairly constructed and consistently enforced. To that end, Witherington and Martin (2003) suggest a basic framework for a Lighting Ordinance that includes descriptions of activities prohibited because of their disruption to sea turtle nesting, standards for new lighting, standards for mitigating existing lighting, and proposals for enforcement and monitoring. These, along with other general issues that should be addressed in a Lighting Ordinance are explored in this section, including the extent to which this framework can apply to Anguilla's special needs and, finally, suggestions as to how these issues can be most effectively addressed.

IDENTIFY CRITICAL HABITAT

Implementation of a Lighting Ordinance must be based on current knowledge of which coastal areas support sea turtle nesting. With an aim to characterize the status of the island's sea turtle populations and active threats to their survival, DFMR has been collecting data on active nesting and foraging sites on the island since 1995. With the intention of encouraging recovery of nesting populations, the Department seeks to protect beaches that are currently used for nesting, as well as those which have historically had nesting (James Gumbs, DFMR, personal communication).

According to DFMR records, these beaches would include:

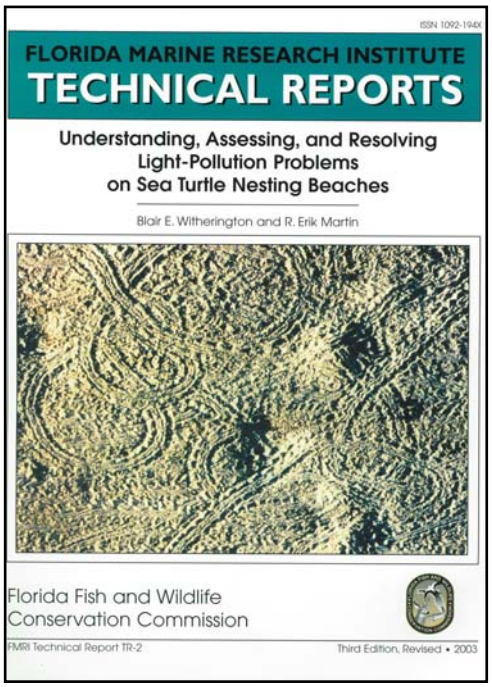
Katouche Bay, Crocus Bay, Little Bay, Limestone Bay, Blackgarden Bay, Shoal Bay East, Island Harbour, Captain's Bay, Windward Point, Savannah Bay, Mimi's Bay, Sandy Hill Bay, Long Pond Beach, Forest Bay, Corito Bay, Elsie Bay, Little Harbour, Lockrum Bay, Old Woman's Bay, Sandy Point, Rendezvous Bay, Cove Bay, Maunday's Bay, Shoal Bay West, West End by the Sea, Barnes Bay, Mead's Bay, Long Bay, Road Bay, and Auntie Doo Bay.

Of these, the most recently active sites are (in order of activity): Captain's Bay, Windward Point, Savannah Bay, Long Bay, Limestone Bay, Blackgarden Bay, Mead's Bay, Shoal Bay West, Barnes Bay, Cove Bay, Crocus Bay, Katouche Bay, Junk's Hole, Mimi's Bay, Sandy Hill Bay, Shoal Bay East, and Road Bay (Godley et al., 2004).

Adopt Model Standards for New Lighting

In general, amendments to lighting should be enforced during all dark hours to ensure that no early- or late-emerging turtles are affected (Witherington et al., 1990), and it should be kept in mind that development distant from the nesting beach can also have lighting impacts (e.g., Philibosian, 1976). Personal explanations provided to stakeholders, and brochures or other visual representations provided to hoteliers and homeowners, will help to emphasize what is considered acceptable and unacceptable with regard to lighting regimes.

Adapting model text presented by Witherington and Martin (2003) to Anguilla, we recommend that Government adopt the following standards for artificial lighting sources on all new coastal construction: [7]



1. Exterior lighting should be designed and positioned so that:
    a. The point source of light or any reflective surface of the light fixture is not directly visible from the nesting beach; and
    b. The nesting beach is not indirectly illuminated by reflective surfaces near lights; for example, walls, pavement, swimming pools, umbrellas, and so on.

2. Exterior light fixtures visible from the beach are considered appropriately designed if:
    a. Fixtures are completely shielded, downlit, and/or recessed with low wattage (<50 W incandescent equivalent[8]); emit long wave lengths (e.g., "bug" type bulbs); and feature non-reflective interior surfaces. Other fixtures with appropriate shields, louvers, or cutoff features may also be used if they are in compliance with subsections 1(a) and 1(b) above; and
    b. All fixtures are mounted as low to the ground as possible through the use of low-mounted wall fixtures, low bollards, and ground-level fixtures.

3. Floodlights, uplights or spotlights for decorative and accent purposes that are directly visible from the beach, or which indirectly or cumulatively illuminate the beach, should not be used.

[7] A glossary of terms is provided in Appendix E.

[8] Florida Fish and Wildlife Conservation Commission (http://www.myfwc.com/WILDLIFEHABITATS/Seaturtle_Lighting.htm#Solutions%20to%20Decrease%20Light-Pollution) recommends 25 watts or less for incandescent and 9 watts or less for compact fluorescent bulbs.

4. Exterior lights used expressly for safety or security purposes should be limited to the minimum number and configuration required to achieve their functional role(s). Where possible, motion detector switches that turn lights on only when approached should be used, and should be programmed to illuminate for the minimum duration.

5. Only low intensity lighting should be used in parking areas within line-of-sight of the beach. Such lighting should be:
    a. Set on a base that raises the source of light no higher than 48 inches from the ground; and
    b. Positioned or shielded so that the light is cast downward and away from the beach, and neither the light source nor any reflective surface of the light fixture is visible from the beach or can be seen to directly or indirectly illuminate the nesting beach.

6. Parking areas and roadways, including any paved or unpaved areas upon which motorized vehicles will park or operate, should be designed and located to prevent vehicular headlights from shining (directly or indirectly) on portions of the nesting beach.

7. Vehicular lighting, parking area lighting, and roadway lighting should be shielded from the beach through the use of vegetation or other ground-level barriers that do not interfere with sea turtle nesting or hatchling emergence, or cause short- or long-term damage to the nesting beach.

8. Tinted glass should be installed on all windows and glass doors of single or multi-story structures within line-of-sight of the beach.

9. Use of appropriately shielded low-pressure sodium vapor lamps and fixtures should be used for high-intensity lighting applications, such as lighting parking areas and roadways, providing security, and similar applications.

10. Temporary lighting of construction sites during the sea turtle nesting season should be restricted to the minimal amount necessary and should incorporate all of the standards articulated in this section.

Adopt Model Standards for Existing Lighting

Witherington and Martin (2003) recommend slightly different language in order to provide "the highest level of protection for nesting sea turtles and their hatchlings" through modification of existing lighting regimes. By emphasizing the intended result – i.e., darkening the beach as much as possible – rather than implementation of specific technologies, property owners are given the flexibility to design and implement strategies that are most appropriate and cost-effective for a particular site.

Adapting the model to Anguilla, the following text is recommended:

1. Existing artificial light fixtures should be repositioned, modified, or removed so that:
    a. The point source of light or any reflective surface of the light fixture is not directly visible from the nesting beach; and
    b. The nesting beach is not indirectly illuminated by reflective surfaces near lights; for example, walls, pavement, swimming pools, umbrellas, and so on.

2. The following measures should be taken to reduce or eliminate the negative effects of existing exterior lighting: [9]
    a. Reposition fixtures so that the point source of light or any reflective surface of the light fixture is no longer visible from the beach;
    b. Replace fixtures having an exposed light source with fixtures containing recessed light sources or shields;
    c. Replace traditional bulbs with low wattage (<50 W incandescent equivalent[10]), long wavelength bulbs (e.g., yellow "bug" type, amber LED, red LED);
    d. Replace non-directional fixtures with directional fixtures that point downward and away from the beach;
    e. Replace fixtures having transparent or translucent coverings with fixtures having opaque shields covering an arc of at least 180º and extending an appropriate distance below the bottom edge of the fixture on the seaward side so that neither the light source nor any reflective surface of the fixture is visible from the beach;
    f. Replace pole lamps with low-profile, low-level lights so neither the light fixture nor any reflective surface of the fixture is visible from the beach;
    g. Replace incandescent, fluorescent, and high intensity lighting with the lowest wattage, low pressure sodium-vapor lighting suitable for the application;
    h. Plant or improve vegetation barriers between light sources and the beach to help screen light from the beach, or construct a ground-level barrier to achieve the same purpose (the ground-level barrier must not interfere with sea turtle nesting or hatchling emergence, or cause short- or long-term damage to the beach); and
    i. Permanently remove or permanently disable any fixture which cannot be brought into compliance with the provisions of these standards.

3. The following measures should be taken to reduce or eliminate the negative effects of interior light associated with doors and windows visible from the nesting beach:
    a. Apply window tint or film that meets the standards for tinted glass;
    b. Rearrange lamps and other moveable fixtures away from windows;
    c. Use window treatments (e.g., blinds, curtains) to shield interior lights from the beach and encourage guests to close their curtains at night during the nesting and hatching season; and
    d. Turn off all unnecessary lights; remind guests to turn lights off when not in use.

Bonfires on sea turtle nesting beaches attract and burn hatchlings. Photo by Alicia Marin.

Prohibit Other Light Sources

The following activities involving direct illumination of a nesting beach should also be prohibited at night during sea turtle nesting and hatching seasons:

[9] With these requirements in mind, landowners and property managers should be encouraged to mitigate in ways most appropriate and cost-effective to their property, as long as the mandated result – no artificial light visible from the nesting beach – is achieved. Remember, if you can see the light, so can the sea turtle!

[10] Florida Fish and Wildlife Conservation Commission (http://www.myfwc.com/WILDLIFEHABITATS/Seaturtle_Lighting.htm#Solutions%20to%20Decrease%20Light-Pollution) recommends 25 watts or less for incandescent and 9 watts or less for compact fluorescent bulbs.

a. The operation of all motorized vehicles, except emergency and law enforcement vehicles; and
b. The building of campfires or bonfires on (or in line-of-sight of) the nesting beach.

Support Law Enforcement

When determining penalties related to the timeframe within which properties must come into compliance or degrees of offence, many factors must be taken into consideration. Fines must be sufficient to encourage compliance, but reasonable enough so that authorities are willing to invoke them. Fines should escalate with repeat offences. When considering rental properties, consideration must be given to whether liability falls to the owner and/or occupant. Incentives for compliance should be provided, and enforcement authorities clearly defined.

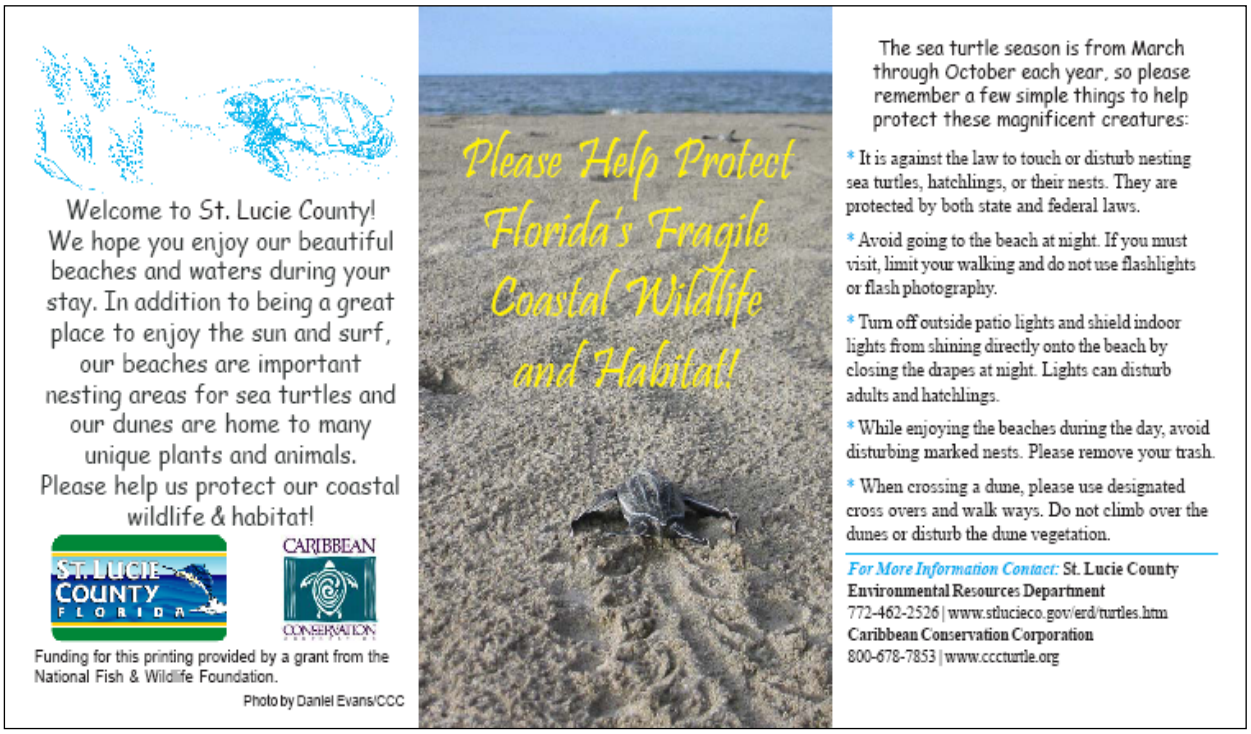
A national Lighting Ordinance should require compliance at all (current and historic) documented nesting beaches. Enforcement priority, in the context of limited resources, should be directed at major nesting beaches with the most deleterious lighting regimes. For example, Captain's Bay not only has high numbers of sea turtles nesting but an adjoining villa, Exclusivity, focuses intense floodlights on the beach all night. Therefore, Captain's Bay should be considered a high priority, both for mitigation and for enforcement of compliance.

Encourage Public Awareness

Witherington and Martin (2003) conclude that "making the public aware of light-pollution problems on sea turtle nesting beaches is a fundamental step towards darkening beaches for sea turtles. Many of those responsible for errant lighting are unaware of its detrimental effects and are generally willing to correct the problem voluntarily once they become aware." To encourage awareness, Rupert Balgobin (Head Engineer, Cuisinart Resort and Spa, personal communication) relates that guests are informed at Check-in that the resort is "lucky to be on a sea turtle nesting beach", and asked to kindly close their blinds when interior lights are in use, to turn lights off when not in use, and to refer to related information available in the rooms.

Hotel manager assists DFMR officer measure a sea turtle nesting crawl. This manager regularly cordons off crawls and nest sites on his property until DFMR staff arrive to document the event.

Involving managers and guests in awareness campaigns can emphasize the value and vulnerability of nesting beaches, and offer a uniquely satisfying vacation experience to guests who actively respond to requests designed to promote sea turtle survival. With this in mind, attention should be paid to the development of concise, attractive messages (e.g., brochures, in-room 'table tents') suitable for residents and tourists alike (see insert, next page).



Encourage Citizen Reporting

Staff and resource limitations conspire to ensure that DFMR cannot unilaterally monitor sea turtle nesting island-wide or stay abreast of incidents of disorientation due to beachfront lighting. Public participation in reporting sea turtle sightings is critical to understanding population trends and patterns of habitat usage, and how these might be affected by implementation of light mitigation schemes.

DFMR currently receives reports of nesting from some hotel managers, but not all hotel staff are aware of how to proceed after a turtle sighting. For example, a grounds manager at Covecastles recounted to the Assessor that he had observed nesting at his property, but did not know whom to call. Since many property and grounds managers are on the beach during early morning and early evening hours, they are an important asset in monitoring nesting and hatching activity, as well as lighting compliance. A brochure explaining a simple protocol for hotel staff to follow would be useful.

A 24-hour *Sea Turtle Hotline* should be maintained for public reporting of sea turtle sightings, illegal activity, and emergencies. A national *Hotline* has proven effective on other Caribbean islands (e.g., Dominica: Byrne and Eckert, 2006; Barbados: Beggs et al., 2007) in encouraging public involvement and vigilance.

SUMMARY AND CONCLUSIONS

The British Overseas Territory of Anguilla is home to four species of endangered sea turtle; three of these nest on the island's sandy beaches. The island is also home to a vibrant tourism industry, the demands of which are evident in the rapid development of the island's coastline. Beachfront development is directly implicated in habitat encroachment and loss (e.g., Cambers, 2003), as well as reduced survival of sea turtles due to artificial beachfront lighting that causes adult females and their newly hatched young to travel inland instead or orienting properly to the sea (Godley et al., 2004). Such lighting may also discourage females from nesting and/or displace them into less suitable (but unlit) nesting habitat, further reducing the survival prospects of the hatchlings (Witherington and Martin, 2003).

The untimely death of sea turtle hatchlings due to artificial beachfront lighting is not a trivial concern. In one quantified study, in Barbados between 1998 and 2000, ca. 65% (n=329) of hawksbill sea turtle nests laid on lighted beaches along the south coast and 33% (n=556) of nests laid on lighted beaches along the west coast "suffered some degree of hatchling disorientation", involving *tens of thousands* of hatchlings – and the percentage of post-nesting females disoriented by lights increased each year (Eckert and Horrocks, 2002).

When it became clear to the Department of Fisheries and Marine Resources that managing direct take of sea turtles (through a legislated moratorium) was unlikely, by itself, to result in population recovery, DRMR reached out to WIDECAST for assistance in evaluating the effects of tourism development on sea turtle survival in Anguilla. Specifically, the Department was interested in mitigating the potentially negative effects of artificial beachfront lighting and requested a lighting assessment of selected properties, with policy recommendations.

The senior author and Assessor, Ms. Kimberley Lake, with Mr. James Gumbs, Director of DFMR, at a press conference in 2007 to discuss the issues associated with beachfront lighting.

In response, a project was carried out in partnership with Government and selected property owners who were approached ahead of time and agreed to participate. Planning and collaboration between property owners and the lighting assessment team ensured both transparency and mutual respect. The primary outcomes of the project were written Lighting Assessment Reports for participating hoteliers (see Appendices B, C, D) and draft text and recommendations for a national Lighting Ordinance (see "Basic Components for a Lighting Ordinance").

Lighting Assessment Reports feature the location, fixture type, and "rank" of each light, a photograph of the fixture, notes, and specific recommendations for reducing negative effects on sea turtles. Each Report has been peer-reviewed and approved by the property manager and other partners. With regard to policy recommendations, whether to hoteliers or to Government (e.g., Lighting Ordinance), we focused on results, not technology, inviting property managers to solve the problem in site-appropriate ways.

Opportunities and obstacles to mitigation are apparent. One opportunity is the timing of the peak tourism season, which does not coincide with peak turtle nesting (March to September), meaning that lighting adjustments could be focused on darkening nesting beaches when fewer tourists are on site. Another advantage is the exclusive tourism product that Anguilla represents, and the expectation that the coveted "only person on the island" feeling would not be expected to conflict with reduced lighting on the island's sandy beaches.

Obstacles include safety and security concerns, the variety of property types that contribute to the island's light pollution problem, lack of a national policy regarding beachfront lighting, low levels of public awareness concerning the threat posed to endangered sea turtles, and the difficulty hoteliers operating on a small island might experience in obtaining "sea turtle friendly" lighting technologies.

It is our hope that amid the many challenges inherent in protecting important sea turtle nesting grounds in Anguilla, that participating resorts will take the recommendations of the Lighting Assessment Reports to heart, that other hotels in Anguilla will take similar action to help reduce the impact the tourism industry has had on sea turtles nesting on the island. Moreover, we hope that Government will continue to promote sea turtle conservation and management programs, encourage private sector involvement, and advocate for a comprehensive Lighting Ordinance as part of the island's regulatory framework.

Hatchling leatherback sea turtles orienting correctly to the sea. Photo by David Southall.

The project provides a useful contemporary example of how academic, private, nonprofit, and government entities can work together to find management solutions to biodiversity threats in tourism-based economies.

As many Caribbean countries support a coastal tourism product important to their economic health, and many of these same countries support remnant populations of sea turtles in need of conservation attention, the project also provides a model for finding solutions to beachfront lighting at other Caribbean destinations.

In closing, it is useful to note that coastal development tied to the tourism industry brings a host of challenges for management, of which artificial lighting is but one. Dow et al. (2007) cite beach sand mining, recreational equipment and other obstacles present on hotel beaches, frequent beach driving, loss of native vegetation to development, and beach erosion. Choi and Eckert (2009) provide more detail and offer specific recommendations. By addressing threats posed by beachfront lighting, Anguilla creates awareness and capacity to solve other tourism-related threats, especially as they pertain to the coastal zone, an environment vital to the security, economy, and culture of the island.

LITERATURE CITED

Anguilla Tourist Board. 2006. Press Release February 2006, "Anguilla Tourist Board Announces 19% Increase in Visitor Arrivals for 2005." http://www.onecaribbean.org/information/documentview.php?rowid=3761

Beggs, J., J.A. Horrocks and B. Krueger. 2007. Increase in hawksbill, *Eretmochelys imbricata*, sea turtle nesting in Barbados, West Indies. Endangered Species Research 3:159-168.

Bell, C.D., J.L. Solomon, J.M. Blumenthal, T.J. Austin, G. Ebanks-Petrie, A.C. Broderick and B. J. Godley. 2007. Monitoring and conservation of critically reduced marine turtle nesting populations: lessons from the Cayman Islands. Animal Conservation 10:9-47.

Bräutigam, A. and K.L. Eckert. 2006. Turning the Tide: Exploitation, Trade and Management of Marine Turtles in the Lesser Antilles, Central America, Colombia and Venezuela. TRAFFIC International. Cambridge, UK. 551 pp. http://www.widecast.org/Resources/Pubs.html

Byrne, R. and K.L. Eckert. 2006. 2004-2005 Biennium Project Report: Rosalie Sea Turtle Initiative (RoSTI). Prepared by WIDECAST for the Ministry of Agriculture and the Environment (Forestry, Wildlife and Parks Division). Roseau, Dominica, West Indies. 51 pp.

Cambers, G. 1997. Planning for Coastline Change: Guidelines for Construction Setbacks in the Eastern Caribbean Islands. CSI Information Document 4. UNESCO, Paris. 14 pp.

Cambers, G. 2003. Coping with Beach Erosion in Anguilla. UNESCO: United Nations Educational, Scientific and Cultural Organization. Paris, France. 10 pp. http://www.unesco.org/csi/act/cosalc/angb.pdf

Choi, G.-Y. and K.L. Eckert. 2009. Manual of Best Practices for Safeguarding Sea Turtle Nesting Beaches. Wider Caribbean Sea Turtle Conservation Network (WIDECAST) Technical Report No. 9. Ballwin, Missouri. 86 pp. http://www.widecast.org/Resources/Pubs.html

CIA. 2009. The World Factbook: Anguilla. https://www.cia.gov/library/publications/the-world-factbook/geos/av.html; last accessed on 14 August 2009.

Dow, W., K. Eckert, M. Palmer and P. Kramer. 2007. An Atlas of Sea Turtle Nesting Habitat for the Wider Caribbean Region. The Wider Caribbean Sea Turtle Conservation Network and The Nature Conservancy. WIDECAST Technical Report No. 6. Beaufort, North Carolina. 267 pp. + electronic Appendices. http://seamap.env.duke.edu/widecast/

Eckert, K.L. and J.A. Horrocks (Editors). 2002. Proceedings of "Sea Turtles and Beachfront Lighting: An Interactive Workshop for Industry Professionals and Policy-Makers in Barbados", 13 October 2000. Sponsored by WIDECAST, the Barbados Sea Turtle Project, and the Tourism Development Corporation of Barbados. WIDECAST Technical Report 1. 43 pp. http://www.widecast.org/Resources/Pubs.html

Encyclopædia Britannica. 2008. Geography and Travel: Anguilla. http://www.britannica.com/EBchecked/topic/25267/Anguilla; last accessed on 16 November 2009.

Frazer, N.B. 1986. Survival from egg to adulthood in a declining population of loggerhead turtles, *Caretta caretta*. Herpetologica 42(1):47-55.

Frazier, J. 2003. Prehistoric and ancient historic interactions between humans and marine turtles, p.1-38. In: P.L. Lutz, J.A. Musick and J. Wyneken (Editors), The Biology of Sea Turtles, II. CRC Press, Boca Raton, Florida.

Gell, F. and M. Watson. 2000. UK Overseas Territories in the Northeast Caribbean: Anguilla, British Virgin Islands, Montserrat, p.615-626. In: Charles Sheppard (Editor), Seas at the Millennium: An Environmental Evaluation, Volume I, Regional Chapters: Europe, The Americas and West Africa. Pergamon Press.

Godley B.J., A.C. Broderick, L.M. Campbell, S Ranger and P.B. Richardson. 2004. An Assessment of the Status and Exploitation of Marine Turtles in Anguilla, p.39-77. In: An Assessment of the Status and Exploitation of Marine Turtles in the UK Overseas Territories in the Wider Caribbean, Final Project Report for the Department of Environment, Food and Rural Affairs and the Foreign and Commonwealth Office, UK. http://www.widecast.org/What/Country/Anguilla/anguilla.html

Government of Anguilla. 2005. "STATIPS" for the Month of May 2005: Tourism. 3 pp.

Heppell, S.S., L.B. Crowder and T.R. Menzel. 1999. Life table analysis of long-lived marine species with implications for management, p.137-148. In: J.A. Musick (Editor), Life in the Slow Lane: Ecology and Conservation of Long-Lived Marine Animals. American Fisheries Society Symposium 23. American Fisheries Society, Bethesda, Maryland.

Heppell, S.S., D.T. Crouse and L.B. Crowder. 2000. Using matrix models to focus research and management efforts in conservation, p.148-168. In: S. Ferson and M. Burgman (Editors), Quantitative Methods for Conservation Biology. Springer-Verlag, Berlin.

Heppell, S.S., D.T. Crouse, L.B. Crowder, S.P. Epperly, W. Gabriel, T. Henwood, R. Márquez and N.B. Thompson. 2004. A population model to estimate recovery time, population size and management impacts on Kemp's ridley sea turtles. Chelonian Conservation and Biology 4(4):767-773.

Knowles, J.E. 2007. In the Spotlight: An Assessment of Beachfront Lighting at Four Hotels and Recommendations for Mitigation Necessary to Safeguard Sea Turtles Nesting in Barbados, West Indies. Thesis, Master of Environmental Management, Nicholas School of the Environment and Earth Sciences, Duke University. Durham, North Carolina. 149 pp.

Lake, K.N. 2008. Mitigating Anthropogenic Lighting on Sea Turtle Nesting Beaches in Anguilla: Recommendations for a Lighting Ordinance in Tourism-Based Economy. Thesis, Master of Environmental Management, Nicholas School of the Environment and Earth Sciences, Duke University. Durham, North Carolina. 67 pp.

Limpus, C.J., V. Baker and J.D. Miller. 1979. Movement induced mortality of loggerhead eggs. Herpetologica 35(4):335-338.

Marcovaldi, G., M. Angela and J.C.A. Thorne. 1999. Reducing threats to sea turtles, p.165-168. In: K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly (Editors), Research and

Management Techniques for the Conservation of Seat Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4. Washington, D.C. http://www.iucn-mtsg.org/publications/

Margoluis, R. and N. Salafsky. 1998. Measures of Success: Designing, Managing, and Monitoring Conservation and Development Projects. Island Press, Washington D.C. 362 pp.

McFarlane, R.W. 1963. Disorientation of loggerhead hatchlings by artificial road lighting. Copeia 1963(1):153.

McNeely, J.A. (Editor). 1995. Expanding Partnerships in Conservation. Island Press, Washington D.C. 302 pp.

Ministry of Economic Development. 2005. Visitor Exit Survey Report: June 2005. Statistics Department, Ministry of Economic Development, Investment, Commerce and Tourism. Government of Anguilla. 19 pp. http://www.gov.ai/statistics/images/Visitor%20Exit%20_2005.pdf

Philibosian, R. 1976. Disorientation of hawksbill turtle hatchlings, *Eretmochelys imbricata*, by stadium lights. Copeia 1976(4):824.

Petersen, J.B. 1997. Taino, Island Carib, and prehistoric Amerindian economies in the West Indies: tropical forest adaptations to island environments, p.118-130. In: S.M. Wilson (Editor), Indigenous Peoples of the Caribbean. University Press of Florida, Gainesville.

Peterson J.B. and J.G. Crock. 2001. The Amerindians of Anguilla. A publication of the Anguilla Archeological and Historical Society.

Ramsay, M. and R. Newton. 1991. The Effect of Better Street Lighting on Crime and Fear: A Review. Crime Prevention Unit Paper 29. Home and Office Crime Prevention Unit, London.

Salmon, M. 2003. Artificial night lighting and sea turtles. Biologist 50(4):163-168.

Salmon, M., R. Reiners, C. Lavin and J. Wyneken. 1995a. Behavior of loggerhead sea turtles on an urban beach I: hatchling orientation. Journal of Herpetology 29(4):560-567.

Salmon, M., M.G. Tolbert, D.P. Painter, M. Goff, and R. Reiners. 1995b. Behavior of loggerhead sea turtles on an urban beach II: hatchling orientation. Journal of Herpetology 29(4):568-576.

Tuxbury, S.M., and M. Salmon. 2005. Competitive interactions between artificial lighting and natural cues during sea-finding by hatchling marine turtles. Biological Conservation 121(2): 311-316.

UNESCO-CSI. 1997. Beach erosion in Anguilla. Brochure, Sea Grass Printers. The Valley, Anguilla. http://www.unesco.org/csi/act/cosalc/projec10.htm

Versteeg, A.H., J. Tacoma and P. van de Velde. 1990. Archaeological Investigations on Aruba: The Malmok Cemetery. Publication of the Archaeological Museum Aruba no. 2.

Witherington, B.E. 1991. Orientation of hatchling loggerhead turtles at sea off artificially lighted and dark beaches. Journal of Experimental Marine Biology and Ecology 149:1-11.

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

Witherington, B.E. 1999. Reducing Threats to Nesting Habitat, p.179-183. In: K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly (Editors), Research and Management Techniques for the Conservation of Seat Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4. Washington, D.C. http://www.iucn-mtsg.org/publications/

Witherington, B.E. and K.A. Bjorndal. 1991a. Influences of wavelength and intensity on hatchling sea turtle phototaxis: implications for sea-finding behavior. Copeia 1991(4):1060-1069.

Witherington, B.E. and K.A. Bjorndal. 1991b. Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles *Caretta caretta*. Biological Conserv. 55(2):139-149.

Witherington, B.E and R.E. Martin. 2003. Understanding, Assessing and Resolving Light Pollution Problems on Sea Turtle Nesting Beaches, Third Edition revised. Florida Marine Research Institute Technical Reports, TR-2. St. Petersburg, Florida. 73 pp. http://research.myfwc.com/publications/publication_info.asp?id=39080

Witherington, B.E., K.A. Bjorndal and C.M. McCabe. 1990. Temporal pattern of nocturnal emergence of loggerhead turtle hatchlings from natural nests. Copeia 1990(4):1165-1168.

Yancey, K.B. Where the elite retreat. USA Today, 8 January 2008. Online edition.

Assessor (second from right), DFMR staff and volunteers after a successful sea turtle sampling event on Scrub Island, off the coast of Anguilla. Photo courtesy of DFMR.

APPENDIX A

Lighting Evaluation Form

Facility Name/Address: _____

Light Location: _____

Type of Observation (Circle): Daytime Early Nighttime Late Nighttime Follow-up Nighttime

Date/Time of Observation: _____

Observer(s): _____

General Comments: _____

_____

_____

_____

_____

Light Visible From Beach: YES NO

Fixture Type: _____ Photo #: _____

Rank: 1 2 3 OFF NOB

Comments: _____

_____

Recommended Modifications: _____

_____

_____

_____

_____

Observed Modifications: _____

_____

Additional Modifications Required: YES NO

APPENDIX B

Lighting Assessment Report

Prepared for:

CUISINART RESORT AND SPA

Rendezvous Bay
Anguilla, British West Indies

Assessment Performed by:
Kimberley Lake, Duke University

In Partnership with:
Department of Fisheries and Marine Resources, Anguilla
Wider Caribbean Sea Turtle Conservation Network (WIDECAST)

INTRODUCTION

Four species of endangered sea turtle contribute to the ecological wealth of Anguilla, British West Indies. Three of these species – the leatherback, hawksbill, and green turtle – nest seasonally (peak: March to September) on beaches around the island. Centuries of largely unmonitored exploitation have resulted in population declines (Godley et al., 2004); in response, Government has enforced a moratorium on the harvest of sea turtles and their eggs since 1995.

While safeguarding remnant stocks from unsustainable use is an important step in population recovery, equally important is the protection of essential breeding habitat. Because sea turtles must return to the ocean after laying their eggs, and they orient themselves using subtle light cues, the presence of artificial light shining on nesting beaches – sometimes referred to as "light pollution" – can be detrimental to gravid females and their hatchlings (summarized by Witherington and Martin, 2003). In an attempt to document this threat at known nesting beaches in Anguilla, and to formulate recommendations for mitigation, formal lighting assessments were performed during July and August 2007 in partnership with the Department of Fisheries and Marine Resources and the Wider Caribbean Sea Turtle Conservation Network (WIDECAST).

Sea turtles nest most successfully on dark, quiet beaches. Emerging hatchlings align themselves with the brightest ambient cues, which, under natural conditions are associated with the open horizon and reflective surface of the ocean, as opposed to the landward vegetation or dune line. This journey must take place quickly or hatchlings become tired, dehydrated, and/or an easy meal for predators. However, on a lit beach, hatchlings, in particular, can be drawn to artificial light sources instead of to the water. Disoriented and confused, the newborn turtles wander inland, often dying before they can reach the sea.

On islands characterized by coastal tourism and development, where beaches cannot feasibly be dark and quiet year-round, it is vital that coastal properties use best lighting practices to minimize their impacts on nearby sandy beaches. Property owners and managers are most directly involved in establishing best lighting practices through their participation in a lighting assessment and its recommendations. Property owners and managers have unique knowledge of the location and purpose of each lighting fixture; moreover, they know, for example, which lights are under the control of the property and which are controlled by guests and clients.

By involving owners and managers from the start, the negative effects of beachfront lights can be mitigated in ways that are cost-effective, energy-reducing, and aesthetically pleasing, as well as practical from a facilities management standpoint.

The Cuisinart Resort and Spa, along with three other properties, graciously volunteered to have a lighting assessment performed on their property from June to August 2007. In doing so, they have assumed a leadership role in the conservation and recovery of local sea turtle populations. As management commits to implementation of the following recommendations, the property will continue to set an example for other beachfront properties to follow.

Mr. Rupert Balgobin, Head Engineer (Cuisinart Resort and Spa), participated fully in all stages of the assessment, providing access to the property, information about the lights, and volunteering lighting mitigation ideas. This is exactly the type of collaborative effort that will pay large and measurable dividends in restoring sea turtle populations in Anguilla. Since the resort is located on one of the island's most active nesting beaches, implementation of the recommendations will significantly benefit local sea turtles by contributing to high quality nesting grounds.

Lighting Assessment Overview

Lighting assessments were performed by Kimberley Lake (graduate student, Nicholas School of the Earth and Environmental Sciences, Duke University) on July 2, 2007. An initial daytime assessment was performed at 1500 hr, an early nighttime assessment was performed at 1930 hr, and a late nighttime assessment was performed at 2400 hr (midnight). Because lights are often managed differently depending on time of day, multiple sequential assessments allow the Assessor to capture the temporal aspects of lighting effects. As the purpose of the study was to evaluate these effects on sea turtles, all assessments were performed from the nesting beach. The Assessor accessed the property behind the beach only to verify the source of an indirect light, or to verify the type and placement of a specific light fixture.

Daytime Assessments

The purpose of a daytime lighting assessment is to document and record any light fixture that can be seen from the beach. In this case the Assessor walked from one beachfront end of the property to the other, documenting the types of light fixtures, as well as their locations and quantities. Photographs of each fixture type were taken to facilitate off-property verification and to identify each fixture in the Lighting Assessment Report (see "Rankings and Recommendations"). Once nighttime assessments were completed, a follow-up daytime walk along the property with Mr. Balgobin helped to verify and document the uses and importance of each light fixture, as well as the exact timing of their illumination.

Early Nighttime Assessments

The purpose of the early nighttime assessment is to determine the potential impact (to nesting sea turtles and their young) of each light fixture identified during the daytime assessment. During this assessment, the Assessor assigns a rank to each problematic light fixture – with '1' being the least disruptive and '3' being the most disruptive. An ideal score of zero ('0') would indicate that there is no need for mitigation measures.

A light with a rank of '1' is typically an indirect light, or a light where the globe is not visible from the beach; such a light is not strong enough to cast a shadow on the beach surface. A light with a rank of '2' has a globe that can be seen from the beach, but the light is not strong enough to cast a shadow on the surface of the beach. A light with a rank of '3' is strong enough to cast a shadow on the beach, whether the globe is visible or not. It is noteworthy that lights of various rankings can be either outdoor or indoor lights, the latter sometimes bright enough to be seen from the beach and to have a disorienting effect on sea turtles.

To ensure that each light was assigned an accurate rank, hotel personnel were, in some cases, asked to extinguish confounding lights while a specific fixture was being assessed.

Late Nighttime Assessment

To capture the temporal aspects of the beachfront lighting at a particular property, a late nighttime assessment (methodologically a repeat of the early nighttime assessment) is crucial. For example, a restaurant may be brightly lit most of the evening, with a variety of lights clearly visible from the nesting beach, but after midnight these lights are extinguished and cease to exert a measurable impact on nesting or hatchling turtles. Understanding the nature and extent of each light fixture, and the task it performs, is important to the development of an accurate and useful roster of mitigation recommendations.

REDUCING LIGHTING THREATS TO SEA TURTLES: GENERAL PRINCIPLES [11]

There are many ways that beachfront property owners can modify their lights to prevent them from being seen from the nesting beach. The following is a list of suggestions. Note that these solutions may need to be used in conjunction with one another in order to most effectively prevent sea turtle disorientation.

- Turn off unnecessary lights. Do not use decorative lighting (such as runner lights or uplighting of vegetation) in areas that are visible from the beach and permanently remove, disable, or turn off fixtures that cannot be modified in any other way.

- For lights that can be repositioned, face them away from the beach so that the light source is no longer visible from the beach.

- Shield the light source. Materials such as aluminum flashing can be used as a shield to direct light and keep it off the beach. When shielding lights, it is important to make sure that they are shielded from all areas on the beach (including from either side and on top), and not just from the beach directly in front of the light. Black oven paint may be used as a temporary solution.

- Light sockets with an exposed light source (such as plain bulbs) should be replaced with fixtures that are specially made to recess the light source and/or the light source should be shielded.

- Replace fixtures that scatter light in all directions (such as globe lights or carriage lights) with directional fixtures that point down and away from the beach.

- Replace lights on poles with low profile, low-level fixtures so that the light source and reflected light are not visible from the beach.

- Replace incandescent, fluorescent, and high intensity lighting with the lowest wattage low-pressure sodium vapor lighting or replace white incandescent bulbs with the yellow "bug" type light variety of 25 watts or less for incandescent and 9 watts or less for compact fluorescent. The best technology available for “sea turtle friendly” lighting is an amber or red LED lamp.

- Plant or improve vegetation buffers (such as seagrape and other native beach vegetation) between the light source and the beach to screen light from the beach.

- Use shielded motion detector lights for lighting and set them on the shortest time setting.

- To reduce spillover from indoor lighting, move light fixtures away from windows, apply window tint to your windows that meets the 45% inside to outside transmittance standards for tinted glass (you’ll save on air conditioning costs, too!), or use window treatments (blinds, curtains) to shield interior lights from the beach.

[11] Excerpted from the Florida Fish and Wildlife Conservation Commission’s “*Marine Turtles and Lights”*: http://www.myfwc.com/WILDLIFEHABITATS/Seaturtle_Lighting.htm#Solutions%20to%20Decrease%20Light-Pollution. Note that “lamp”, “light source”, and “bulb” are generally used interchangeably.

The Lights of Cuisinart Resort and Spa: Rankings and Recommendations

The following pages document the Assessor's findings. Specific recommendations relied heavily on discussions with the Head Engineer, as well as the standard lighting recommendations found in Witherington and Martin (2003).

Descriptions and recommendations are presented for representative fixture types (e.g., upward-directed floodlight, unshielded bollard), rather than for each individual light source. Recommendations associated with a particular fixture type (e.g., "upward-directed floodlights", as below) *are intended to be implemented each time that specific light fixture occurs on the property*.

Fixtures with a rank of '3' indicate that light is directly visible from the nesting beach, casting a strong shadow and posing a direct threat to endangered sea turtles. Fixtures with a rank of '3' should be addressed as a matter of priority. Commercial sources of "sea turtle friendly" lighting fixtures are identified at the end of the Assessment (see "Online Resources").

Light Location	Beach Bar
Fixture Type	Upward-directed floodlights
Light Ranking	**3**
Notes	(none)
Recommendations	a. Turn lights off when the beach bar is not in use b. Replace the existing fixtures with downlights and use amber or red LED lamps (=light bulbs) c. If it is not possible to replace the existing fixtures, then use the lowest wattage lamps available, point the fixtures downward, and apply shields that will block the source of light from the beach

Beach Bar – upward-directed floodlights

Light Location	Access pathways between villas
Fixture Type	Unshielded bollards
Light Ranking	**3**
Notes	There is a lot of natural vegetation on the property, and most of these fixtures are hidden. The one fixture directly observed from the beach was between Villa 8 and Villa 9. The others, however, did contribute to highly visible reflected light on the lower walls of the villas ("wall wash").
Recommendations	a. Either install louvers and shields on the existing fixtures or replace the existing fixtures with louvered bollards in order to direct light to pathways where it is most needed, and to prevent the spillage of light where it is not needed (i.e., onto the beach and nearby villa walls) b. Same as (a); also consider replacing the existing compact fluorescent lamps with lower wattage compact fluorescent "bug" type lamps

(a) Unshielded bollard
(b) Light from the unshielded bollard reflects on villa walls, causing indirect light known as "wall wash"

Light Location	Main property
Fixture Type	Floodlight
Light Ranking	**3**
Notes	Discussions with management confirm that this light should not be illuminated on a daily basis, but is only used for special events. This powerful light has the potential to be very distracting to sea turtles when in use.
Recommendations	a. Point the fixture downward (away from the beach, if possible) b. Attach a full visor to effectively shield the light from the beach c. Consider a lower wattage, full-cutoff (ideally low-pressure sodium vapor) fixture

Floodlight in front of property, highly visible from the nesting beach

Light Location	Bell towers atop villas
Fixture Type	Unknown, assume spotlight
Light Ranking	**3**
Notes	Lights serve an aesthetic purpose important to the showcasing of the property
Recommendations	a. Use a much lower wattage lamp (preferably an amber or red LED) to reduce the intensity of the wall wash b. Turn lights off during sea turtle nesting and hatching seasons c. At a minimum, turn these lights off after 2300 hr during sea turtle nesting and hatching seasons

Bell tower lights, highly visible from the nesting beach

Light Location	Second and third floor balconies
Fixture Type	Wall-mounted up/down lighting
Light Ranking	2
Notes	These fixtures effectively prevent horizontal light spillage. However, since they allowed light to go upward, wall wash was very strong from these fixture types. On the first floor, landscaped foliage effectively shielded the light from the nesting beach.
Recommendations	a. Verbally remind guests at Check-in and with in-room materials to be mindful of their lights, and to turn balcony lights off when not in use b. Cap the fixture (e.g., attach a shield on the top of the fixture) to cancel the up-lighting c. Use a lower wattage lamp (preferably an amber or red LED) to light the balcony but not the adjoining nesting beach

(a) Wall-mounted up/down lighting
(b) Wall wash creates a glow visible from the nesting beach

Light Location	Beach Bar stairway
Fixture Type	Wall-mounted steplight with visor
Light Ranking	2
Notes	These lights are installed with a timer so that only the lights in the bend of the stairway are illuminated all night; however, the light could still be seen at angles. These lights are important for guest safety.
Recommendations	a. Use an amber or red LED lamp or a lower wattage “bug” type light

Wall-mounted stairway steplight with visor

Light Location	Second and third floor rooms
Fixture Type	Interior room lights
Light Ranking	1
Notes	There are reminders in the rooms to keep blinds drawn, and to turn lights off when not in use. As a result, this fixture type is generally well managed; however, more should be done to ensure that beachfront rooms do not emit a distracting glow to the nesting beach.
Recommendations	a. Verbally remind guests upon Check-in, and with in-room materials, to be mindful of their lights, and to draw their curtains at night b. Black-out curtains should be standard issue in beachfront rooms

Indirect lighting from guest rooms when curtains are open

Where to Begin? Useful Online Resources Include the Following:

Witherington and Martin (2003), *Understanding, Assessing and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches*: http://research.myfwc.com/publications/publication_info.asp?id=39080

Florida Fish and Wildlife Conservation Commission, *Florida Marine Turtle Program (including "Marine Turtles & Lights")*: http://myfwc.com/seaturtle/

FFWCC/USFWS, *Wildlife Lighting Certification Program*: http://www.myfwc.com/conservation/Conservation_LivingWith_WildlifeLighting_index.htm

WIDECAST, *Conservation Threats and Solutions*: http://www.widecast.org/Conservation/Threats.html

International Dark-Sky Association (including approved fixtures): http://www.darksky.org/

Starry Night Lights (including approved fixtures): http://www.starrynightlights.com/

Acknowledgements

Sincere thanks to Cuisinart Resort and Spa for providing access to their beautiful property and to their staff, and especially to Mr. Rupert Balgobin who participated in the assessment process and was crucial to our understanding of the property's lighting regime. This Lighting Assessment Report also benefited from a detailed review by Mr. Erik Martin, Ecological Associates Inc. (Florida).

Special thanks are also extended to Mr. James Gumbs, Director of the Department of Fisheries and Marine Resources (and WIDECAST Country Coordinator in Anguilla), and to Farah Mukhida of the Anguilla National Trust, who personally escorted the Assessor during nighttime assessments. Mr. Gumbs generously arranged partnerships with the properties involved; and his staff was patient and generous with their time and expertise. Finally, Mr. Rhon Connor (Department of Environment) and his family provided excellent accommodations for the Assessor during her stay on-island.

Literature Cited

Godley B.J., A.C. Broderick, L.M. Campbell, S. Ranger and P.B. Richardson. 2004. An Assessment of the Status and Exploitation of Marine Turtles in Anguilla, pp.39-77. In: An Assessment of the Status and Exploitation of Marine Turtles in the UK Overseas Territories in the Wider Caribbean. Final Project Report for the Department of Environment, Food and Rural Affairs and the Foreign and Commonwealth Office. London, U.K.

Witherington, B.E. and R.E. Martin. 2003. Understanding, Assessing, and Resolving Light Pollution Problems on Sea Turtle Nesting Beaches, Revised Edition. Florida Marine Research Institute Technical Report TR-2. 73 pp.

APPENDIX C

Lighting Assessment Report

Prepared for:
FRANGIPANI BEACH RESORT

Meads Bay
Anguilla, British West Indies

Assessment Performed by:
Kimberley Lake, Duke University

In Partnership with:
Department of Fisheries and Marine Resources, Anguilla
Wider Caribbean Sea Turtle Conservation Network (WIDECAST)

INTRODUCTION

Four species of endangered sea turtle contribute to the ecological wealth of Anguilla, British West Indies. Three of these species – the leatherback, hawksbill, and green turtle – nest seasonally (peak: March to September) on beaches around the island. Centuries of largely unmonitored exploitation have resulted in population declines (Godley et al., 2004); in response, Government has enforced a moratorium on the harvest of sea turtles and their eggs since 1995.

While safeguarding remnant stocks from unsustainable use is an important step in population recovery, equally important is the protection of essential breeding habitat. Because sea turtles must return to the ocean after laying their eggs, and they orient themselves using subtle light cues, the presence of artificial light shining on nesting beaches – sometimes referred to as "light pollution" – can be detrimental to gravid females and their hatchlings (summarized by Witherington and Martin, 2003). In an attempt to document this threat at known nesting beaches in Anguilla, and to formulate recommendations for mitigation, formal lighting assessments were performed during July and August 2007 in partnership with the Department of Fisheries and Marine Resources and the Wider Caribbean Sea Turtle Conservation Network (WIDECAST).

Sea turtles nest most successfully on dark, quiet beaches. Emerging hatchlings align themselves with the brightest ambient cues, which, under natural conditions are associated with the open horizon and reflective surface of the ocean, as opposed to the landward vegetation or dune line. This journey must take place quickly or hatchlings become tired, dehydrated, and/or an easy meal for predators. However, on a lit beach, hatchlings, in particular, can be drawn to artificial light sources instead of to the water. Disoriented and confused, the newborn turtles wander inland, often dying before they can reach the sea.

On islands characterized by coastal tourism and development, where beaches cannot feasibly be dark and quiet year-round, it is vital that coastal properties use best lighting practices to minimize their impacts on nearby sandy beaches. Property owners and managers are most directly involved in establishing best lighting practices through their participation in a lighting assessment and its recommendations. Property owners and managers have unique knowledge of the location and purpose of each lighting fixture; moreover, they know, for example, which lights are under the control of the property and which are controlled by guests and clients.

By involving owners and managers from the start, the negative effects of beachfront lights can be mitigated in ways that are cost-effective, energy-reducing, and aesthetically pleasing, as well as practical from a facilities management standpoint.

The Frangipani Beach Resort, along with three other properties, graciously volunteered to have a lighting assessment performed on their property from June to August 2007. In doing so, they have assumed a leadership role in the conservation and recovery of local sea turtle populations. As management commits to implementation of the following recommendations, the property will continue to set an example for other beachfront properties to follow.

Mr. Esmond Richards, a member of the Resort's maintenance team, participated fully in all stages of the assessment, providing access to the property, information about the lights, and volunteering lighting mitigation ideas. This is exactly the type of collaborative effort that will pay large and measurable dividends in restoring sea turtle populations in Anguilla. Since the resort is located on one of the island's most active nesting beaches, implementation of the recommendations will significantly benefit local sea turtles by contributing to high quality nesting grounds.

Lighting Assessment Overview

Lighting assessments were performed by Kimberley Lake (graduate student, Nicholas School of the Earth and Environmental Sciences, Duke University) on July 3, 2007. An initial daytime assessment was performed at 1300 hr, an early nighttime assessment was performed at 2000 hr, and a late nighttime assessment was performed at 2400 hr (midnight). Because lights are often managed differently depending on time of day, multiple sequential assessments allow the Assessor to capture the temporal aspects of lighting effects. As the purpose of the study was to evaluate these effects on sea turtles, all assessments were performed from the nesting beach. The Assessor accessed the property behind the beach only to verify the source of an indirect light, or to verify the type and placement of a specific light fixture.

Daytime Assessments

The purpose of a daytime lighting assessment is to document and record any light fixture that can be seen from the beach. In this case the Assessor walked from one beachfront end of the property to the other, documenting the types of light fixtures, as well as their locations and quantities. Photographs of each fixture type were taken to facilitate off-property verification and to identify each fixture in the Lighting Assessment Report (see "Rankings and Recommendations"). Once nighttime assessments were completed, a follow-up daytime walk along the property with Mr. Richards helped to verify and document the uses and importance of each light fixture, as well as the exact timing of their illumination.

Early Nighttime Assessments

The purpose of the early nighttime assessment is to determine the potential impact (to nesting sea turtles and their young) of each light fixture identified during the daytime assessment. During this assessment, the Assessor assigns a rank to each problematic light fixture – with '1' being the least disruptive and '3' being the most disruptive. An ideal score of zero ('0') would indicate that there is no need for mitigation measures.

A light with a rank of '1' is typically an indirect light, or a light where the globe is not visible from the beach; such a light is not strong enough to cast a shadow on the beach surface. A light with a rank of '2' has a globe that can be seen from the beach, but the light is not strong enough to cast a shadow on the surface of the beach. A light with a rank of '3' is strong enough to cast a shadow on the beach, whether the globe is visible or not. It is noteworthy that lights of various rankings can be either outdoor or indoor lights, the latter sometimes bright enough to be seen from the beach and to have a disorienting effect on sea turtles.

To ensure that each light was assigned an accurate rank, hotel personnel were, in some cases, asked to extinguish confounding lights while a specific fixture was being assessed.

Late Nighttime Assessment

To capture the temporal aspects of the beachfront lighting at a particular property, a late nighttime assessment (methodologically a repeat of the early nighttime assessment) is crucial. For example, a restaurant may be brightly lit most of the evening, with a variety of lights clearly visible from the nesting beach, but after midnight these lights are extinguished and cease to exert a measurable impact on nesting or hatchling turtles. Understanding the nature and extent of each light fixture, and the task it performs, is important to the development of an accurate and useful roster of mitigation recommendations.

REDUCING LIGHTING THREATS TO SEA TURTLES: GENERAL PRINCIPLES [12]

There are many ways that beachfront property owners can modify their lights to prevent them from being seen from the nesting beach. The following is a list of suggestions. Note that these solutions may need to be used in conjunction with one another in order to most effectively prevent sea turtle disorientation.

- Turn off unnecessary lights. Do not use decorative lighting (such as runner lights or uplighting of vegetation) in areas that are visible from the beach and permanently remove, disable, or turn off fixtures that cannot be modified in any other way.

- For lights that can be repositioned, face them away from the beach so that the light source is no longer visible from the beach.

- Shield the light source. Materials such as aluminum flashing can be used as a shield to direct light and keep it off the beach. When shielding lights, it is important to make sure that they are shielded from all areas on the beach (including from either side and on top), and not just from the beach directly in front of the light. Black oven paint may be used as a temporary solution.

- Light sockets with an exposed light source (such as plain bulbs) should be replaced with fixtures that are specially made to recess the light source and/or the light source should be shielded.

- Replace fixtures that scatter light in all directions (such as globe lights or carriage lights) with directional fixtures that point down and away from the beach.

- Replace lights on poles with low profile, low-level fixtures so that the light source and reflected light are not visible from the beach.

- Replace incandescent, fluorescent, and high intensity lighting with the lowest wattage low-pressure sodium vapor lighting or replace white incandescent bulbs with the yellow "bug" light variety of 25 watts or less for incandescent and 9 watts or less for compact fluorescent. The best technology available for “sea turtle friendly” lighting is an amber or red LED.

- Plant or improve vegetation buffers (such as seagrape and other native beach vegetation) between the light source and the beach to screen light from the beach.

- Use shielded motion detector lights for lighting and set them on the shortest time setting.

- To reduce spillover from indoor lighting, move light fixtures away from windows, apply window tint to your windows that meets the 45% inside to outside transmittance standards for tinted glass (you’ll save on air conditioning costs, too!), or use window treatments (blinds, curtains) to shield interior lights from the beach.

[12] Excepted from the Florida Fish and Wildlife Conservation Commission’s “*Marine Turtles and Lights”*: http://www.myfwc.com/WILDLIFEHABITATS/Seaturtle_Lighting.htm#Solutions%20to%20Decrease%20Light-Pollution. Note that “lamp”, “light source”, and “bulb” are generally used interchangeably.

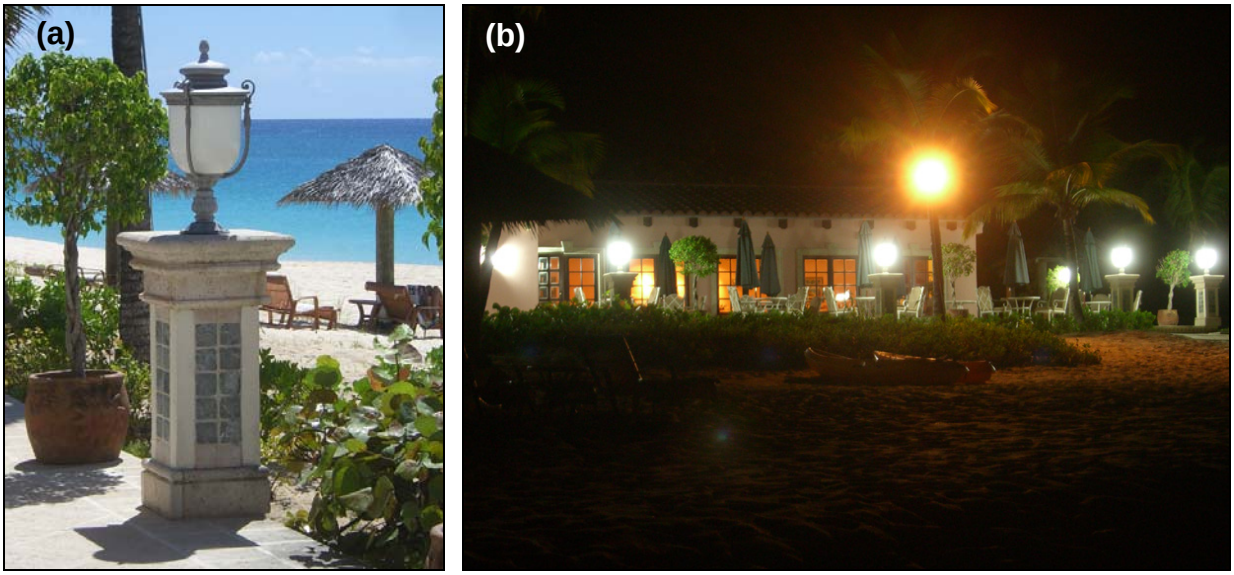
THE LIGHTS OF FRANGIPANI BEACH RESORT: RANKINGS AND RECOMMENDATIONS

The following pages document the Assessor's findings. Specific recommendations relied heavily on discussions with Mr. Esmond Richards, as well as the standard lighting recommendations found in Witherington and Martin (2003).

Descriptions and recommendations are presented for representative fixture types (e.g., pillar-mounted carriage light, tree-mounted flood light), rather than for each individual light source. Recommendations associated with a particular fixture type (e.g., "pillar-mounted carriage light", as below) are intended to be implemented each time that specific light fixture occurs on the property.

Fixtures with a rank of '3' indicate that light is directly visible from the nesting beach, casting a strong shadow and posing a direct threat to endangered sea turtles. Fixtures with a rank of '3' should be addressed as a matter of priority. Commercial sources of "sea turtle friendly" lighting fixtures are identified at the end of the Assessment (see "Online Resources").

Light Location	Surrounding the restaurant patio
Fixture Type	Pillar-mounted period light
Light Ranking	**3**
Notes	These very bright lights are illuminated all night. Positioned directly on the beachfront, the lights pose a strong threat to nesting and hatching sea turtles.
Recommendations	a. Turn lights off when patio is not in use b. Replace lamps (=light bulbs) with low wattage, "sea turtle friendly" lamps and install shields so light sources are not visible from the beach c. Replace fixtures to direct light low and toward the property (away from the beach), focusing on patio areas directly in need of lighting d. Consider decorative landscaping as an additional shield



(a) Pillar mounted period light; (b) Carriage lights illuminated past operation hours illuminate the beach

Light Location	Restaurant patio, beachside
Fixture Type	Tree-mounted floodlight
Light Ranking	**3**
Notes	This very bright light is mounted high, and oriented such that it illuminates a large portion of the nesting beach.
Recommendations	a. Replace the fixture with one that will be compatible with a "sea turtle friendly" lamp; the replacement fixture should be designed and positioned so that it illuminates the minimum area necessary to achieve the intended purpose b. Attach a motion sensor to the light

Floodlight mounted high on a palm tree illuminates the beach

Light Location	Pathway to beach
Fixture Type	Low-level, tier lighting
Light Ranking	**3**
Notes	These lights are necessary for guest safety. The fixture is designed well for the nesting beach, eliminating most horizontal light. However, the lamp is too bright and can serve its purpose with much lower wattage.
Recommendations	a. Replace existing lamps with lower wattage, "sea turtle friendly" lamps b. As needed, shield portions of some lights to limit beach illumination c. Alternatively, these lights could be replaced with similar low-level fixtures that direct the light more downward d. Install a motion sensor e. Limit the distance these lights extend out onto the beach

Low-level tier lighting illuminate guests' path to the beach

Light Location	Western end (front) of the guest house and in front of the concierge house
Fixture Type	Medium wall-mounted carriage light
Light Ranking	**3**
Notes	These lights, three in each location (see above), are very bright. The ones at the western end of the property do not directly illuminate anything but the beach, and the concierge house is not used at night, suggesting, in both cases, that the fixtures are not essential to the lighting requirements of the property.
Recommendations	a. Turn these lights off during the annual nesting season

(a) Medium wall-mounted carriage light, illuminated during the day; (b) Effects of lights on beach

Light Location	Entrance to Beachfront Grill
Fixture Type	Large wall-mounted period light
Light Ranking	**3**
Notes	(none)
Recommendations	a. Turn lights off when not in use b. Replace existing lamps with low wattage, “sea turtle friendly” lamps and install shields so light sources are not visible from the beach c. Replace fixture with downlighting

Large wall-mounted period light

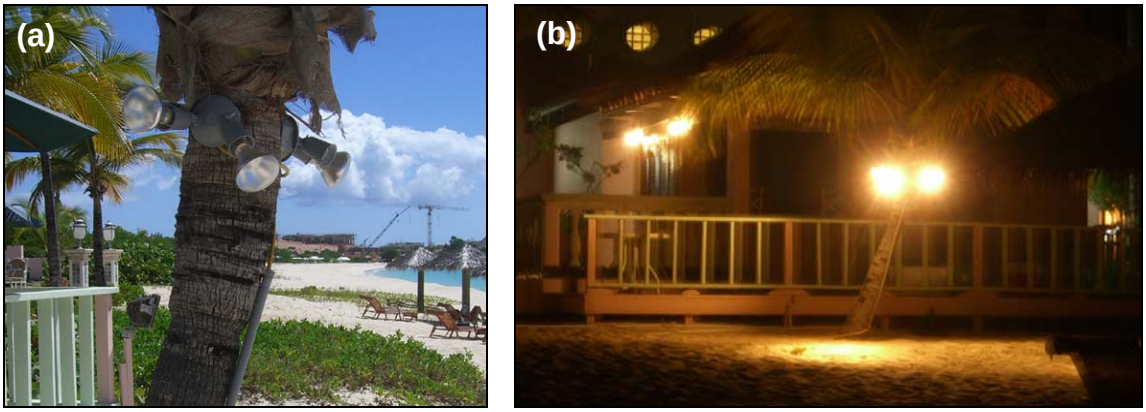
Light Location	Mounted on either side of the doorframes on most guesthouse, beachfront walls
Fixture Type	Small wall-mounted carriage light
Light Ranking	**3**
Notes	(none)
Recommendations	a. Replace all existing lamps with low wattage, "sea turtle friendly" lamps and install shields so light sources are not visible from the beach b. During nesting season, remind guests at Check-in and place reminders in rooms to turn these lights off when not in use c. Replace all fixtures with downlighting

Small wall-mounted carriage light

Light Location	Concierge stand
Fixture Type	Low pole-mounted floodlight
Light Ranking	**3** (if used)
Notes	This light was not on during the assessment, and Mr. Richards informed me that the light is permanently unplugged. Nevertheless, the fixture is troubling because it has the potential to be extremely distracting to sea turtles if turned on.
Recommendations	a. Remove the light fixture completely

Unused pole-mounted floodlight

Light Location	In front of beach bar (two lights); at the eastern end of property (one light)
Fixture Type	Tree-mounted double spotlight
Light Ranking	**3**
Notes	These lights are normally turned on and also used for special events. However, they are aimed toward the beach and light a significant portion of it strongly; therefore, they present a threat to nesting and hatching sea turtles.
Recommendations	a. Replace the existing lamps with "sea turtle friendly" lamps b. Attach hoods on the spotlights and direct them down and toward the temporary bar, minimizing light spillage onto beach



(a) Tree mounted double spotlight in front beach bar; (b) Effects of event spotlight illuminated at night

Light Location	Western boundary wall (two lights); parking area (one light); pool (five lights)
Fixture Type	Pole-mounted period light
Light Ranking	2
Notes	(none)
Recommendations	a. Lower the fixtures, and replace fixtures with downlighting b. Attach motion sensors to the fixtures by the pool so lights are on at night only when the pool is in use c. Increase beachfront vegetation to shield the beach from these lights

Pole-mounted period light

Light Location	Guests Rooms
Fixture Type	Indoor lights
Light Ranking	1
Notes	(none)
Recommendations	a. During the nesting season, remind guests at Check-in – and place reminders in rooms – to turn lights off when not in use, and to pull the blinds at night

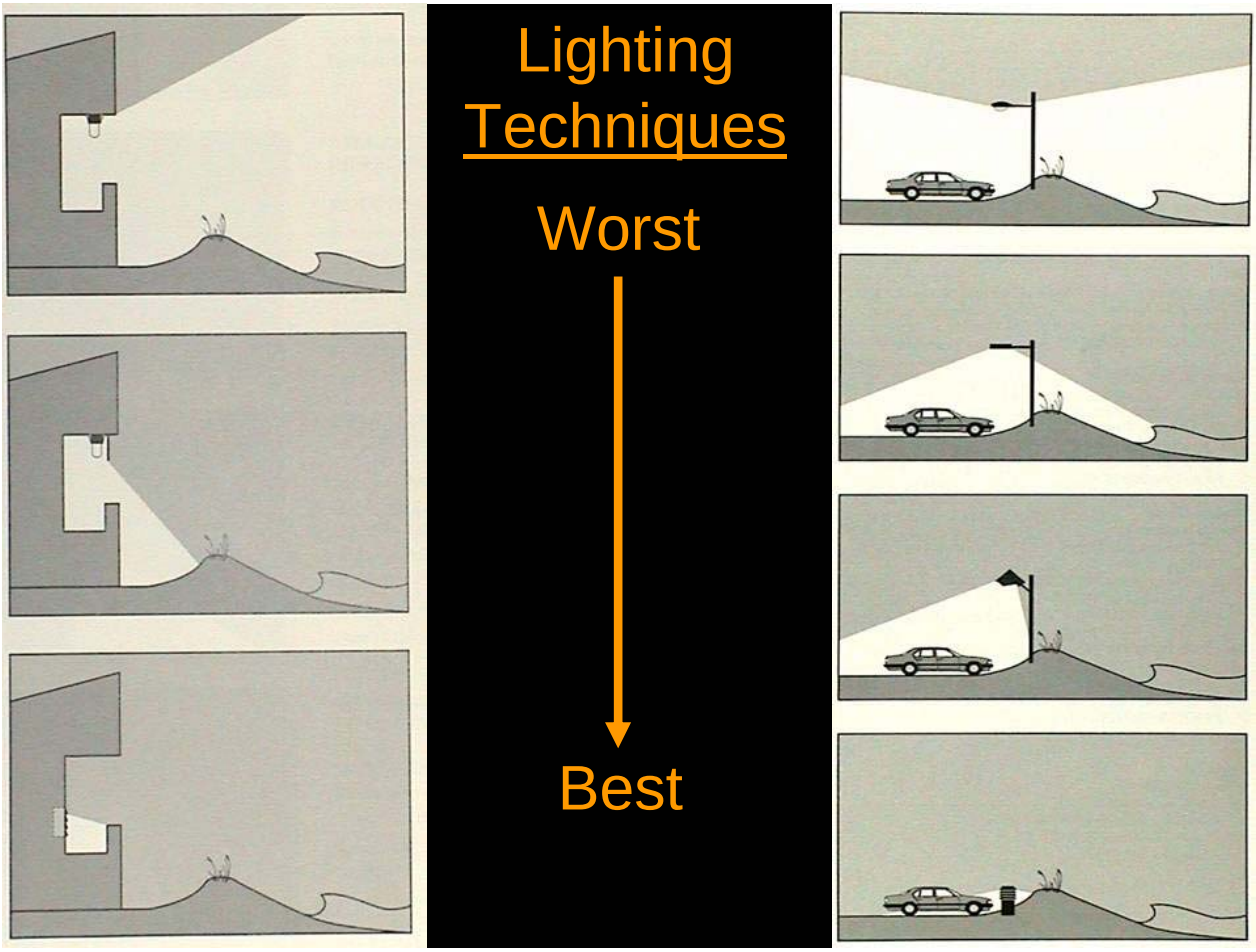
Indirect lighting from guest rooms at night

Light Location	Restaurant
Fixture Type	Indoor lights
Light Ranking	1
Notes	(none)
Recommendations	a. Replace restaurant lights with lower wattage, more intimate lighting b. Close window coverings at night c. Turn off lights when not in use

Lights from within the restaurant after dining room is closed

ADDITIONAL COMMENTS

Frangipani Beach Resort's impending remodel presents an ideal opportunity for the resort to change its lighting regime to reduce the threat posed to nesting and hatching sea turtles by artificial beachfront lighting. "Sea turtle friendly" lamps (light bulbs), fixtures, and other elements are found at many outdoor lighting retailers on the Internet (see "Online Resources" on the next page). With planning and foresight, lighting can be designed to shine only where it is needed, thereby achieving its objective without excessive light pollution spilling onto nearby nesting beaches.



Consider where light is actually needed, and install lighting to meet the need (source: Witherington and Martin, 2003).

Where to Begin? Useful Online Resources Include the Following:

Witherington and Martin (2003), *Understanding, Assessing and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches*: http://research.myfwc.com/publications/publication_info.asp?id=39080

Florida Fish and Wildlife Conservation Commission, *Florida Marine Turtle Program (including "Marine Turtles & Lights")*: http://myfwc.com/seaturtle/

FFWCC/USFWS, *Wildlife Lighting Certification Program*: http://www.myfwc.com/conservation/Conservation_LivingWith_WildlifeLighting_index.htm

WIDECAST, *Conservation Threats and Solutions*: http://www.widecast.org/Conservation/Threats.html

International Dark-Sky Association (including approved fixtures): http://www.darksky.org/

Starry Night Lights (including approved fixtures): http://www.starrynightlights.com/

Acknowledgements

Sincere thanks to the Frangipani Beach Resort, and especially to Office Manager Susan Brookes for providing access to the property and to her staff, and to Mr. Esmond Richards who participated in the assessment process and was crucial to our understanding of the property's lighting regime. This Lighting Assessment Report also benefited from a detailed review by Mr. Erik Martin, Ecological Associates Inc. (Florida).

Special thanks are also extended to Mr. James Gumbs, Director of the Department of Fisheries and Marine Resources (and WIDECAST Country Coordinator in Anguilla), and to Farah Mukhida of the Anguilla National Trust, who personally escorted the Assessor during nighttime assessments. Mr. Gumbs generously arranged partnerships with the properties involved; and his staff was patient and generous with their time and expertise. Finally, Mr. Rhon Connor (Department of Environment) and his family provided excellent accommodations for the Assessor during her stay on-island.

Literature Cited

Godley B.J., A.C. Broderick, L.M. Campbell, S. Ranger and P.B. Richardson. 2004. An Assessment of the Status and Exploitation of Marine Turtles in Anguilla, pp.39-77. In: An Assessment of the Status and Exploitation of Marine Turtles in the UK Overseas Territories in the Wider Caribbean. Final Project Report for the Department of Environment, Food and Rural Affairs and the Foreign and Commonwealth Office. London, U.K.

Witherington, B.E. and R.E. Martin. 2003. Understanding, Assessing, and Resolving Light Pollution Problems on Sea Turtle Nesting Beaches, Revised Edition. Florida Marine Research Institute Technical Report TR-2. 73 pp.

APPENDIX D

Lighting Assessment Report

Prepared for:
COVECASTLES

Shoal Bay West
Anguilla, British West Indies

Assessment Performed by:
Kimberley Lake, Duke University

In Partnership with:
Department of Fisheries and Marine Resources, Anguilla
Wider Caribbean Sea Turtle Conservation Network (WIDECAST)

INTRODUCTION

Four species of endangered sea turtle contribute to the ecological wealth of Anguilla, British West Indies. Three of these species – the leatherback, hawksbill, and green turtle – nest seasonally (peak: March to September) on beaches around the island. Centuries of largely unmonitored exploitation have resulted in population declines (Godley et al., 2004); in response, Government has enforced a moratorium on the harvest of sea turtles and their eggs since 1995.

While safeguarding remnant stocks from unsustainable use is an important step in population recovery, equally important is the protection of essential breeding habitat. Because sea turtles must return to the ocean after laying their eggs, and they orient themselves using subtle light cues, the presence of artificial light shining on nesting beaches – sometimes referred to as "light pollution" – can be detrimental to gravid females and their hatchlings (summarized by Witherington and Martin, 2003). In an attempt to document this threat at known nesting beaches in Anguilla, and to formulate recommendations for mitigation, formal lighting assessments were performed during July and August 2007 in partnership with the Department of Fisheries and Marine Resources and the Wider Caribbean Sea Turtle Conservation Network (WIDECAST).

Sea turtles nest most successfully on dark, quiet beaches. Emerging hatchlings align themselves with the brightest ambient cues, which, under natural conditions are associated with the open horizon and reflective surface of the ocean, as opposed to the landward vegetation or dune line. This journey must take place quickly or hatchlings become tired, dehydrated, and/or an easy meal for predators. However, on a lit beach, hatchlings, in particular, can be drawn to artificial light sources instead of to the water. Disoriented and confused, the newborn turtles wander inland, often dying before they can reach the sea.

On islands characterized by coastal tourism and development, where beaches cannot feasibly be dark and quiet year-round, it is vital that coastal properties use best lighting practices to minimize their impacts on nearby sandy beaches. Property owners and managers are most directly involved in establishing best lighting practices through their participation in a lighting assessment and its recommendations. Property owners and managers have unique knowledge of the location and purpose of each lighting fixture; moreover, they know, for example, which lights are under the control of the property and which are controlled by guests and clients.

By involving owners and managers from the start, the negative effects of beachfront lights can be mitigated in ways that are cost-effective, energy-reducing, and aesthetically pleasing, as well as practical from a facilities management standpoint.

Covecastles, along with three other properties, graciously volunteered to have a lighting assessment performed on their property from June to August 2007. In doing so, they have assumed a leadership role in the conservation and recovery of local sea turtle populations. As management commits to implementation of the following recommendations, the property will continue to set an example for other beachfront properties to follow.

Mr. Robert Murray (Property Engineer) participated fully in all stages of the assessment, providing access to the property, information about the lights, and volunteering lighting mitigation ideas. This is exactly the type of collaborative effort that will pay large and measurable dividends in restoring sea turtle populations in Anguilla. Since the resort is located on one of the island's most active nesting beaches, implementation of these recommendations will significantly benefit local sea turtles by contributing to high quality nesting grounds.

Lighting Assessment Overview

Lighting assessments were performed by Kimberley Lake (graduate student, Nicholas School of the Earth and Environmental Sciences, Duke University) on July 17, 2007. An initial daytime assessment was performed at 0830 hr, an early nighttime assessment was performed at 2000 hr, and a late nighttime assessment was performed at 2400 hr (midnight). Because lights are often managed differently depending on time of day, multiple sequential assessments allow the Assessor to capture the temporal aspects of lighting effects. As the purpose of the study was to evaluate these effects on sea turtles, all assessments were performed from the nesting beach. The Assessor accessed the property behind the beach only to verify the source of an indirect light, or to verify the type and placement of a specific light fixture.

Daytime Assessments

The purpose of a daytime lighting assessment is to document and record any light fixture that can be seen from the beach. In this case the Assessor walked from one beachfront end of the property to the other, documenting the types of light fixtures, as well as their locations and quantities. Photographs of each fixture type were taken to facilitate off-property verification and to identify each fixture in the Lighting Assessment Report (see "Rankings and Recommendations"). Once nighttime assessments were completed, a follow-up daytime walk along the property with Mr. Murray helped to verify and document the uses and importance of each light fixture, as well as the exact timing of their illumination.

Early Nighttime Assessments

The purpose of the early nighttime assessment is to determine the potential impact (to nesting sea turtles and their young) of each light fixture identified during the daytime assessment. During this assessment, the Assessor assigns a rank to each problematic light fixture – with '1' being the least disruptive and '3' being the most disruptive. An ideal score of zero ('0') would indicate that there is no need for mitigation measures.

A light with a rank of '1' is typically an indirect light, or a light where the globe is not visible from the beach; such a light is not strong enough to cast a shadow on the beach surface. A light with a rank of '2' has a globe that can be seen from the beach, but the light is not strong enough to cast a shadow on the surface of the beach. A light with a rank of '3' is strong enough to cast a shadow on the beach, whether the globe is visible or not. It is noteworthy that lights of various rankings can be either outdoor or indoor lights, the latter sometimes bright enough to be seen from the beach and to have a disorienting effect on sea turtles.

To ensure that each light was assigned an accurate rank, hotel personnel were, in some cases, asked to extinguish confounding lights while a specific fixture was being assessed.

Late Nighttime Assessment

To capture the temporal aspects of the beachfront lighting at a particular property, a late nighttime assessment (methodologically a repeat of the early nighttime assessment) is crucial. For example, a restaurant may be brightly lit most of the evening, with a variety of lights clearly visible from the nesting beach, but after midnight these lights are extinguished and cease to exert a measurable impact on nesting or hatchling turtles. Understanding the nature and extent of each light fixture, and the task it performs, is important to the development of an accurate and useful roster of mitigation recommendations.

REDUCING LIGHTING THREATS TO SEA TURTLES: GENERAL PRINCIPLES [13]

There are many ways that beachfront property owners can modify their lights to prevent them from being seen from the nesting beach. The following is a list of suggestions. Note that these solutions may need to be used in conjunction with one another in order to most effectively prevent sea turtle disorientation.

- Turn off unnecessary lights. Do not use decorative lighting (such as runner lights or uplighting of vegetation) in areas that are visible from the beach and permanently remove, disable, or turn off fixtures that cannot be modified in any other way.

- For lights that can be repositioned, face them away from the beach so that the light source is no longer visible from the beach.

- Shield the light source. Materials such as aluminum flashing can be used as a shield to direct light and keep it off the beach. When shielding lights, it is important to make sure that they are shielded from all areas on the beach (including from either side and on top), and not just from the beach directly in front of the light. Black oven paint may be used as a temporary solution.

- Light sockets with an exposed light source (such as plain bulbs) should be replaced with fixtures that are specially made to recess the light source and/or the light source should be shielded.

- Replace fixtures that scatter light in all directions (such as globe lights or carriage lights) with directional fixtures that point down and away from the beach.

- Replace lights on poles with low profile, low-level fixtures so that the light source and reflected light are not visible from the beach.

- Replace incandescent, fluorescent, and high intensity lighting with the lowest wattage low-pressure sodium vapor lighting or replace white incandescent bulbs with the yellow "bug" light variety of 25 watts or less for incandescent and 9 watts or less for compact fluorescent. The best technology available for “sea turtle friendly” lighting is an amber or red LED.

- Plant or improve vegetation buffers (such as seagrape and other native beach vegetation) between the light source and the beach to screen light from the beach.

- Use shielded motion detector lights for lighting and set them on the shortest time setting.

- To reduce spillover from indoor lighting, move light fixtures away from windows, apply window tint to your windows that meets the 45% inside to outside transmittance standards for tinted glass (you’ll save on air conditioning costs, too!), or use window treatments (blinds, curtains) to shield interior lights from the beach.

[13] Excepted from the Florida Fish and Wildlife Conservation Commission’s “*Marine Turtles and Lights”*: http://www.myfwc.com/WILDLIFEHABITATS/Seaturtle_Lighting.htm#Solutions%20to%20Decrease%20Light-Pollution. Note that “lamp”, “light source”, and “bulb” are generally used interchangeably.

THE LIGHTS OF COVECASTLES: RANKINGS AND RECOMMENDATIONS

The following pages document the Assessor's findings. Specific recommendations relied heavily on discussions with Mr. Robert Murray, as well as the standard lighting recommendations found in Witherington and Martin (2003).

Descriptions and recommendations are presented for representative fixture types (e.g., low pole-mounted double spotlight with motion sensor, ceiling mounted downlight), rather than for each individual light source. Recommendations associated with a particular fixture type (e.g., "low pole-mounted double spotlight with motion sensor", as below) are intended to be implemented each time that specific light fixture occurs on the property.

Fixtures with a rank of '3' indicate that light is directly visible from the nesting beach, casting a strong shadow and posing a direct threat to endangered sea turtles. Fixtures with a rank of '3' should be addressed as a matter of priority. Commercial sources of "sea turtle friendly" lighting fixtures are identified at the end of the Assessment (see "Online Resources").

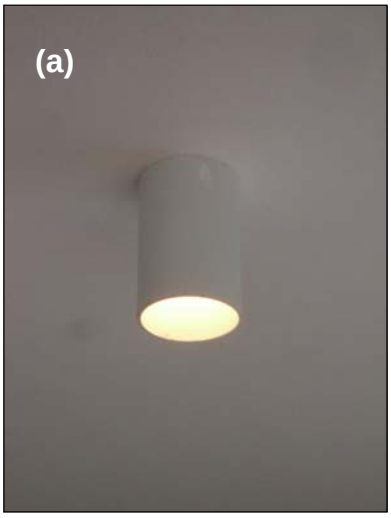
Natural vegetation graces the beachfront along the seaside of Covecastles' villas. At night, lights from the property are rarely visible from the nesting beach.

One of the most striking aspects of this beautiful property is the significant amount of natural vegetation present on the beachfront side of the villas. In some cases, there is even foliage on the beachside of security spotlights. By maintaining natural maritime foliage, Covecastles significantly reduces the effects of lighting emanating from the ground floors of the private villas, and has also made the beach safer and more attractive to nesting turtles. The vegetation not only emphasizes the property's island charm and seclusion, but exemplifies how landscaping can work to the benefit of property owners, guests, and island wildlife.

Light Location	Between the villas
Fixture Type	Low pole-mounted double spotlight with motion sensor
Light Ranking	**3**
Notes	Although these fixtures are present between most villas, the only one functioning during the assessment was between Villa 4 and Villa 5. This light is on a motion sensor, which is commendable, but it is a very strong light source and it was not shielded to prevent horizontal light spillage.
Recommendations	a. Replace existing lamps (=light bulbs) with low wattage, "sea turtle friendly" lamps b. Aim fixture toward property and away from the nesting beach c. Attach a hood to prevent horizontal light spillage d. Plant foliage on the beach side of the fixture to aid in shielding the beach from the light

(a) Low, pole-mounted double spotlight with motion sensor
(b) Activated by a motion sensor, a spotlight illuminates the beach

Light Location	Beachfront patios
Fixture Type	Ceiling-mounted downlight
Light Ranking	**3**
Notes	These lights are mostly shielded from the beach by natural vegetation; however, these lights shine strongly through the pathways from the porch to the beach.
Recommendations	a. Replace existing lamps with lower wattage, "sea turtle friendly" lamps b. Paint interiors of fixtures flat black or install flat black baffles to reduce reflection from interiors of fixtures toward the beach c. During the nesting season, remind guests at Check-in – and place reminders in rooms – to turn lights off when not in use d. Allow foliage to grow higher to shield upper half of porches



(a) Ceiling-mounted downlight
(b) Ceiling downlights illuminate pathways between foliage, and also create intense wall wash on the porches which can be seen in areas where the foliage is less developed

Light Location	Pathway to the beach along the side of Villa 1
Fixture Type	Spotlight
Light Ranking	2
Notes	(none)
Recommendations	a. Turn away from the beach and onto property b. Replace existing lamp with lower wattage “sea turtle friendly” lamp

Pathway spotlight

Light Location	Upper non-beachfront balcony
Fixture Type	Recessed ceiling light
Light Ranking	2/1
Notes	All of these lights create significant wall wash, warranting a rank of at least a 1. Where the actual bulb can be seen, the light warrants a rank of 2.
Recommendations	a. Replace existing lamps with lower wattage “sea turtle friendly” lamps b. Paint interiors of fixtures flat black or install flat black baffles to reduce reflection from interiors of fixtures c. During nesting season, remind guests at Check-in – and place reminders in rooms – to turn lights off when not in use

Wallwash from recessed ceiling light

Light Location	Villa Rooms
Fixture Type	Indoor lights
Light Ranking	1
Notes	(none)
Recommendations	a. During nesting season, remind guests at Check-in – and place reminders in rooms – to draw their curtains at night b. If possible, move lamps away from beachfront sliding glass doors and windows

Indoor lights, visible over tops of foliage

Where to Begin? Useful Online Resources Include the Following:

Witherington and Martin (2003), *Understanding, Assessing and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches*: http://research.myfwc.com/publications/publication_info.asp?id=39080

Florida Fish and Wildlife Conservation Commission, *Florida Marine Turtle Program (including "Marine Turtles & Lights")*: http://myfwc.com/seaturtle/

FFWCC/USFWS, *Wildlife Lighting Certification Program*: http://www.myfwc.com/conservation/Conservation_LivingWith_WildlifeLighting_index.htm

WIDECAST, *Conservation Threats and Solutions*: http://www.widecast.org/Conservation/Threats.html

International Dark-Sky Association (including approved fixtures): http://www.darksky.org/

Starry Night Lights (including approved fixtures): http://www.starrynightlights.com/

Acknowledgements

Sincere thanks to Covecastles, and especially to Ms. Sylvene Petty, Property Manager, for kindly granting access to the property and to her staff, and to Mr. Robert Murray who participated in the assessment process and was crucial to our understanding of the property's lighting regime. This Lighting Assessment Report also benefited from a detailed review by Mr. Erik Martin, Ecological Associates Inc. (Florida).

Special thanks are also extended to Mr. James Gumbs, Director of the Department of Fisheries and Marine Resources (and WIDECAST Country Coordinator in Anguilla), and to Farah Mukhida of the Anguilla National Trust, who personally escorted the Assessor during nighttime assessments. Mr. Gumbs generously arranged partnerships with the properties involved; and his staff was patient and generous with their time and expertise. Finally, Mr. Rhon Connor (Department of Environment) and his family provided excellent accommodations for the Assessor during her stay on-island.

Literature Cited

Godley B.J., A.C. Broderick, L.M. Campbell, S. Ranger and P.B. Richardson. 2004. An Assessment of the Status and Exploitation of Marine Turtles in Anguilla, pp.39-77. In: An Assessment of the Status and Exploitation of Marine Turtles in the UK Overseas Territories in the Wider Caribbean. Final Project Report for the Department of Environment, Food and Rural Affairs and the Foreign and Commonwealth Office. London, U.K.

Witherington, B.E. and R.E. Martin. 2003. Understanding, Assessing, and Resolving Light Pollution Problems on Sea Turtle Nesting Beaches, Revised Edition. Florida Marine Research Institute Technical Report TR-2. 73 pp.

APPENDIX E

Glossary of Terms

Anthropogenic[14] – caused by man

Artificial light, artificial lighting – the light emanating from any human-made device

Beach – the zone of unconsolidated material that extends landward from the mean low water line to the place where there is a marked change in material or physiographic form, or to the line of permanent vegetation, usually the effective limit of storm waves

"Bug" type bulb, "bug light" – any yellow-colored light bulb that is marketed as being specifically treated in such a way so as to reduce the attraction of bugs to the light

Coastal construction activities – any work or activity that is likely to have a material physical effect on existing coastal conditions or natural shore and inlet processes

Cumulatively illuminated – illuminated by numerous artificial light sources that, as a group, illuminate any portion of the beach

Directly illuminated – illuminated as a result of glowing elements(s), lamp(s), globe(s), or reflector(s) of an artificial light source which is visible to an observer on the beach

Ground-level barrier – any vegetation, natural feature or artificial structure rising from the ground that prevents beachfront lighting from shining directly onto the nesting beach

Hatchling – any species of marine turtle, within or outside the nest, recently hatched from an egg

Indirectly illuminated – illuminated as a result of the glowing element(s), lamp(s), globe(s), or reflector(s) of an artificial light source which is not visible to an observer on the beach

LED – Light Emitting Diode; a long-lasting illumination technology that requires very little power

Light pollution – The introduction of artificially produced light into areas where it is neither needed nor desired; at nesting beaches, light pollution negatively affects sea turtle behavior

Sea turtle, marine turtle – one of seven species of ocean-dwelling turtle; these turtles are compelled to return to the land to lay their eggs

[14] Glossary definitions are adapted mainly from Witherington and Martin (2003), pages 71-73.

WIDECAST

Wider Caribbean Sea Turtle Conservation Network

"Working together to build a future where all inhabitants of the Wider Caribbean Region, human and sea turtle alike, can live together in balance."

The Wider Caribbean Sea Turtle Conservation Network (WIDECAST) is a regional coalition of experts and a Partner Organization to the U.N. Environment Programme's Caribbean Environment Programme. WIDECAST was founded in 1981 in response to a recommendation by the IUCN/CCA *Meeting of Non-Governmental Caribbean Organizations on Living Resources Conservation for Sustainable Development in the Wider Caribbean* (Santo Domingo, 26-29 August 1981) that a "Wider Caribbean Sea Turtle Recovery Action Plan should be prepared ... consistent with the Action Plan for the Caribbean Environment Programme."

WIDECAST's vision for achieving a regional recovery action plan has focused on bringing the best available science to bear on sea turtle management and conservation, empowering people to make effective use of that science in the policy-making process, and providing a mechanism and a framework for cooperation within and among nations. By involving stakeholders at all levels and encouraging policy-oriented research, WIDECAST puts science to practical use in conserving biodiversity and advocates for grassroots involvement in decision-making and project leadership.

Emphasizing initiatives that strengthen capacity within participating countries and institutions, the network develops and replicates pilot projects, provides technical assistance, enables coordination in the collection, sharing and use of information and data, and promotes strong linkages between science, policy, and public participation in the design and implementation of conservation actions. Working closely with local communities and resource managers, the network has also developed standard management guidelines and criteria that emphasize best practices and sustainability, ensuring that current utilization practices, whether consumptive or non-consumptive, do not undermine sea turtle survival over the long term.

With Country Coordinators in more than 40 Caribbean nations and territories, WIDECAST is uniquely able to facilitate complementary conservation action across range States, including strengthening legislation, encouraging community involvement, and raising public awareness of the endangered status of the region's six species of migratory sea turtles. As a result, most Caribbean nations have adopted a national sea turtle management plan, poaching and illegal product sales have been dramatically reduced or eliminated at key sites, many of the region's largest breeding colonies are monitored on an annual basis, alternative livelihood models are increasingly available for rural areas, and citizens are mobilized in support of conservation action. You can join us! Visit www.widecast.org for more information.

WWW.WIDECAST.ORG