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BEHAVIORAL RESPONSES OF NESTING SEA TURTLES TO ARTIFICIAL LIGHTING

BLAIR E. WITHERINGTON

Archie Carr Center for Sea Turtle Research and Department of Zoology, University of Florida, Gainesville, FL 32611, USA

ABSTRACT: Effects of artificial lighting on loggerhead (*Caretta caretta*) and green turtle (*Chelonia mydas*) nesting behavior were determined experimentally at major nesting beaches: Melbourne Beach, Florida, USA (loggerheads) and Tortuguero, Costa Rica (green turtles). I conducted experiments in which a portion of each nesting beach remained dark, or was illuminated with white, mercury vapor (MV) or yellow, low pressure sodium vapor (LPS) luminaires of equal luminance. Lighting beaches with MV luminaires significantly reduced the numbers of green turtles and loggerheads emerging and nesting within lighted study areas. Lighting beaches with LPS luminaires had no significant effect on nesting in either species. Some turtles were misdirected by lighted luminaires (primarily mercury vapor) on their return to the ocean following nesting attempts. Lighted luminaires did not significantly affect the stages at which nesting attempts were abandoned nor the positioning of nests relative to dune vegetation. Results suggest that MV luminaires and other broad-spectrum lighting types have the potential to disrupt the nesting of loggerheads and green turtles. LPS luminaires may be an acceptable alternative where lighting on nesting beaches cannot be completely extinguished.

Key words: *Caretta caretta*; *Chelonia mydas*; Light; Nesting behavior; Photopollution; Sea turtle

SEA turtles emerge from the ocean onto sand beaches where they nest. Except for subtle modifications, all species of sea turtles have in common a series of stereotyped nesting behaviors or modal action patterns (Bustard, 1972; Carr et al., 1966; Ehrenfeld, 1979). Although modal action patterns and their sequence during sea turtle nesting are largely constant, some elements of the behavior may vary. Variable elements include where the turtle emerges, where on the beach it begins nest construction, whether or not the nesting attempt is abandoned, what stage is reached before abandonment, and the directness of orientation on the return crawl. This variation in nesting behavior by sea turtles affects successes in egg deposition, in hatchling production, and in the seaward return of the adult (Witherington, 1986).

The conditions that influence variation in sea turtle nesting behavior, such as nest-placement, are poorly known. Two studies correlate nest-site choice with environmental conditions; Mortimer (1982) found that green turtles (*Chelonia mydas*) with a choice of nesting beaches selected those with more open, uncluttered approaches, and Stoneburner and Richardson (1981) found that loggerhead turtles (*Caretta caretta*) moving up a beach tended to nest as they encountered rises in sand temperature. Other environmental cues used by sea turtles to discriminate nesting sites may be visual, as are the cues used by adult sea turtles in relocating the sea (Ehrenfeld and Carr, 1967). Because most species of sea turtles are nocturnal nesters, artificial lighting of nesting beaches may present an environmental modification that disrupts visual cues. The disruptive effect of beach photopollution on the seaward orientation of hatchling sea turtles is well documented (for a review, see Verheijen, 1985).

Increasing human development adjacent to sea turtle nesting beaches worldwide has brought with it increasing levels of artificial illumination. Some authors have observed correlations between lighted, developed beaches and lower nesting activity by sea turtles (Mortimer, 1982; Proffitt et al., 1986; Worth and Smith, 1976). These correlations, however, do not directly implicate lighting as the cause of decreased nesting.

The purpose of this study was to determine experimentally the effects that two forms of artificial lighting have on the nocturnal nesting behavior of green turtles and loggerhead turtles. Aspects of nesting behavior examined included nest-site choice, nest-site abandonment, and seaward orientation of adult females on the nesting beaches.

METHODS

Study Areas

Melbourne Beach.—I chose a 1300 m stretch of east-facing beach, approximately 6.5 km south of the town of Melbourne Beach, Florida, USA, because of the high density (500–700 nests/km/season: Witherington, 1986) of loggerhead turtles nesting there. Work at Melbourne Beach took place between 15 May and 27 June 1989, during the nesting season but prior to the emergence of hatchlings from nests. The study beach was backed by dune scrub and was undeveloped except for a small (50 m length) building with no lighting on the beach side of the building. Other than the single building, and subtle variation in beach width (15–20 m, high water mark to dune vegetation), the study beach appeared homogeneous. The entire monitored study beach remained dark at night, although light from scattered luminaires was visible to the north and south of the study beach boundaries. The primary dune at the site was eroded from a recent storm into a vertical escarpment 3–4 m high. This did not restrict access of turtles to suitable nesting sites. Human presence at night was minimal.

Tortuguero.—I chose a 1450 m stretch of east-facing beach within the Parque Nacional Tortuguero, 15 km south of the Village of Tortuguero, Costa Rica, for the high density (1300–3500 nests/km/season: K. Horikoshi, unpublished data) nesting of green turtles there. Work at Tortuguero took place between 14 July and 16 August 1989, during the nesting season but prior to the emergence of hatchlings from nests. There was no human development within 15 km of the study beach, which was backed by lowland rainforest. The primary dune was low, and the line separating vegetation from beach was roughly defined. Beach width was 3–15 m and varied both according to area of study beach and time of study-period. I maintained a camp at the site, which was not visible from the beach. No other humans were present at the site.

Experimental Design

Melbourne Beach.—I affixed five wooden poles, set 50 m apart, at the edge of the primary dune escarpment in the center of the study beach. Luminaires were mounted on the poles 2 m above the dune and 5–6 m above the berm. Three 650 W portable generators (Honda EG-650) powered the luminaires. Each generator powered one or two luminaires and was housed in a plywood hut positioned 25 m from the nearest luminaire. Additional gasoline reservoirs allowed the generators to run for 12 h (throughout the night). Due to distance, surf-noise, and a predominantly onshore breeze, the sound and smell of running generators were undetectable to a human observer on the lower berm. The study beach was marked every 50 m for 550 m both north and south of the northernmost and southernmost light poles.

I used two experimental treatments, which differed in the type of luminaire that lighted the study beach during a night of nesting. The two experimental treatments were MV (mercury vapor luminaires used, 80 W Innovative Controls Lite Light) and LPS (low pressure sodium vapor luminaires used, 35 W VL Lighting SOX DD-35). In a control treatment, luminaires remained darkened and the generators were not run.

Both MV and LPS luminaires were "dusk-to-dawn" types, each having a circular light distribution with the center of the light field beneath the lamp. I selected wattages of the luminaires so that the MV and LPS types had similar luminance levels—i.e., similar brightness with respect to human photopic vision. Illuminance values at varied distances from single luminaires were similar for the two luminaire types (Table 1). The MV luminaires emitted broad-spectrum "white" light with spectral line peaks near 400, 440, 550, 580, 620, and 700 nm (Licor LI-1800 spectroradiometer). The LPS luminaires appeared yellow, and between 400 and 700 nm, emitted a single spectral line at 590 nm.

I conducted each of the three treatments once, from sunset until sunrise, during each of 14 consecutive three-night blocks between 16 May and 27 June 1989. The order of treatment was randomized within each three-night block.

Tortuguero.—Methods and materials used at Tortuguero were identical to those used at Melbourne Beach except for the following. (1) Six rather than five luminaires per treatment were used and were mounted approximately 50 m apart in the center of the study beach on poles or trees available on site. (2) Luminaires were mounted approximately 2 m above a low primary dune. (3) Generators were housed in thatch huts 4–6 m into the vegetation; each was undetectable to observers on the beach. (4) The study beach was marked each 50 m for 600 m north and south of the northernmost and southernmost luminaires. (5) MV, LPS, and control treatments were conducted in each of 11, three-night blocks from 14 July–16 August 1989. (6) Due to failure of equipment, only the four northernmost luminaires were lighted during MV and LPS treatments in the last three-night block.

TABLE 1.—Illuminance measurements (in lux) taken at varying distances from single luminaires (mercury vapor = MV, or low pressure sodium vapor = LPS) at the Melbourne Beach study area. Measurements were made with a Minolta T-1 illuminance meter at the given lateral distances from the globe of the luminaire. Ambient illuminance with luminaires off was <0.01 lux.

Luminaire	Distance (m) 1	5	10	20
LPS	470	13.0	2.03	0.68
MV	479	6.6	1.36	0.57

Data and Analysis

Assessments of the nightly nesting behavior of green turtles and loggerheads were made through appraisals of crawls left on the beach. Crawls include tracks (marks left in the sand by emerging and returning turtles) and nest sign (marks left by the excavation of body pits and/or egg chambers, or by nest-site obliteration). Surveys of crawls took place shortly after dawn. No nesting turtles emerged during daylight. Because crawls below the recent high tide line could be erased by tides prior to inspection, these crawls were not included in the analysis. During the experiments, only non-nesting crawls fell into this category. The following data were taken for each crawl. (1) Crawl location was measured as the distance of the crawl vertex (point farthest from the surf) from the nearest study area marker. (2) Species of turtle responsible for the crawl was determined by characteristic sign in the beach substrate due to differences in turtle morphology and gait (Pritchard et al., 1983). Sea turtles other than the target species nested at the study beaches in numbers too low for study. (3) Type of crawl was specified as nesting or non-nesting, and if non-nesting, as abandoned during emergence, body pit excavation, or egg chamber excavation (Pritchard et al., 1983). (4) Distance to vegetation was measured as the distance from the crawl vertex (if non-nesting) or the nearest edge of the nest site (if nesting) to the nearest vegetation. (5) Straightness index was measured as the length of the straightest route seaward to the most recent high tide mark, divided by the length of the return track path. Straightness indices <1.0 represent deviations from straightness. Path length was measured from the crawl vertex of crawls with no digging activity and from the most seaward edge of the nest or excavation site of other crawls. Direction of the return (north or south) and a simplified diagram of the crawl also were recorded.

Comparisons among treatments were made using nonparametric statistics (Gibbons, 1985), with $\alpha = 0.05$.

RESULTS

There were 516 loggerhead emergences within the study area at Melbourne Beach, of which 47.1% resulted in nests. At the study beach at Tortuguero, there were 798 green turtle emergences, of which 58.0% resulted in nests. After an exploratory analysis of the spatial distribution of crawl-data, I determined that the area affected maximally by lighted luminaires extended

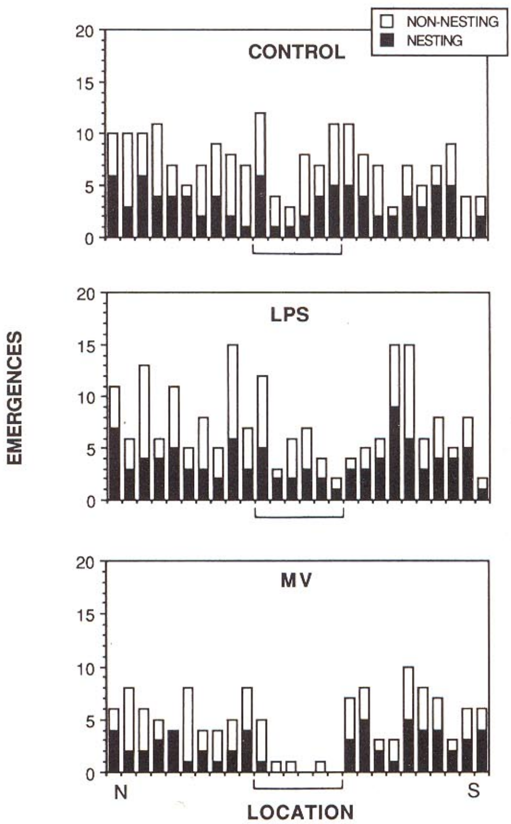

FIG. 1.—Distribution of nesting and non-nesting emergences of loggerhead turtles within the 1300 m study beach at Melbourne Beach, Florida, USA. Location divisions represent 50 m sections. Bracketed sections represent the centrally lighted portion of the study area, which remained dark (control) or was illuminated with either mercury vapor (MV) or low pressure sodium vapor (LPS) luminaires of equal luminance. Peripheral areas include all locations outside the centrally lighted area.

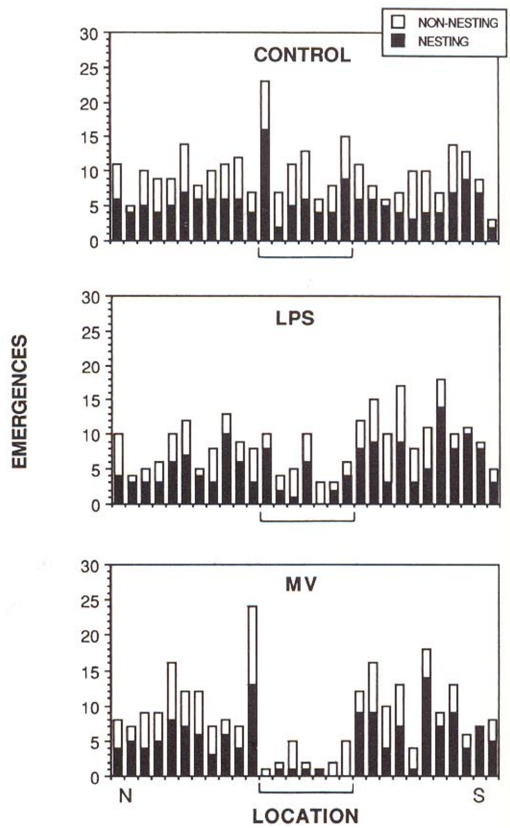

FIG. 2.—Distribution of nesting and non-nesting emergences of green turtles within the 1450 m study beach at Tortuguero, Costa Rica. See legend to Fig. 1.

approximately 50 m from each luminaire (Figs. 1, 2). For further analysis, I divided each study beach into three areas: a central lighted area—including the beach within 50 m of any luminaire —and two peripheral areas—areas of the study beach north and south of the central lighted area. Central lighted areas for Melbourne Beach and Tortuguero were 300 m and 350 m in length, respectively.

There were significantly fewer loggerhead nesting and non-nesting crawls, and green turtle nesting crawls, within the central lighted areas during MV treatment nights, compared with control treatment nights (Table 2). The numbers of nesting and non-nesting loggerhead and green turtle crawls during LPS treatment nights were not significantly different from those numbers during control treatment nights (Table 2). Numbers of nesting and non-nesting crawls within peripheral areas at each study beach did not differ among treatments (Table 2). In a complementary analysis, central lighted areas and peripheral areas during MV treatments for both species were significantly different in the density of nesting and non-nesting crawls (Table 3). Density of nesting and non-nesting crawls were not different between central and peripheral areas in LPS or control treatments for either species (Table 3).

I found no relationship between experimental treatments and the stages at which loggerhead non-nesting emergences were

TABLE 2.—Numbers of nesting and non-nesting emergences of loggerheads and green turtles each night during control (dark beach), low pressure sodium vapor luminaire (LPS), and mercury vapor luminaire (MV) treatments. Emergence locations are either central (within the central study area where luminaires were placed) or peripheral (outside the central area). Statistical values (*H* and *P*) are for Kruskal-Wallis tests among treatments. Different letters within rows indicate significant differences among treatments as detected with a nonparametric multiple comparison test (α = 0.05). Sample size (nights) is constant among treatments for each species (loggerhead, n = 14; green turtle, n = 11).

	$\bar{x}$ emergences ± 1 SD				
	Control	LPS	MV	*H*	*P*
Loggerheads					
Central					
Nesting	1.4 ± 0.9^{A}	1.1 ± 1.1^{A}	0.07 ± 0.27^{B}	17	0.01
Non-nesting	1.9 ± 1.9^{A}	1.4 ± 1.2^{AB}	0.50 ± 1.2^{B}	7.5	0.02
Peripheral					
Nesting	5.0 ± 2.3	5.9 ± 3.5	4.1 ± 2.3	1.7	0.43
Non-nesting	5.8 ± 5.5	5.6 ± 4.0	4.4 ± 2.7	0.3	0.87
Green turtles					
Central					
Nesting	4.2 ± 3.0^{A}	2.1 ± 1.8^{AB}	0.36 ± 0.67^{B}	14	0.01
Non-nesting	3.4 ± 2.5	1.6 ± 1.2	1.3 ± 1.1	4.4	0.11
Peripheral					
Nesting	10 ± 4.3	12 ± 4.7	13 ± 4.7	1.4	0.49
Non-nesting	8.3 ± 4.9	7.6 ± 4.2	8.6 ± 5.2	0.1	0.93

abandoned, either within the entire monitored study beach (χ^2 = 2.12, df = 2, P = 0.35) or within the central lighted area only (χ^2 = 0.041, df = 1, P = 0.84). Nor was such a relationship found for green turtle crawls either within the entire monitored study area (χ^2 = 1.07, df = 2, P = 0.90) or within the central lighted area only (χ^2 = 0.94, df = 2, P = 0.62). No significant difference was found among

TABLE 3.—Density of loggerhead and green turtle nesting and non-nesting emergences among treatments. Statistical values (z and P) are for Mann-Whitney tests between central and peripheral groups. Definition of groups and sample sizes are in Table 2.

	$\bar{x}$ density (emergences/km/night) ± 1 SD			
	Central	Peripheral	z	*P*
Loggerheads				
Control				
Nesting	4.5 ± 3.1	4.9 ± 2.3	0.37	0.36
Non-nesting	6.2 ± 6.2	5.8 ± 5.5	0.09	0.46
LPS				
Nesting	3.6 ± 3.6	5.9 ± 3.7	1.1	0.13
Non-nesting	4.8 ± 4.1	5.6 ± 4.0	0.46	0.32
MV				
Nesting	0.20 ± 0.91	4.1 ± 2.3	4.3	0.0001
Non-nesting	1.7 ± 3.9	4.4 ± 2.7	3.1	0.001
Green turtles				
Control				
Nesting	11.9 ± 8.4	9.6 ± 3.8	0.76	0.22
Non-nesting	9.6 ± 7.1	7.2 ± 4.3	0.66	0.25
LPS				
Nesting	6.0 ± 5.0	10.8 ± 4.3	1.5	0.062
Non-nesting	4.7 ± 3.4	6.9 ± 3.8	0.92	0.18
MV				
Nesting	1.0 ± 1.9	11.6 ± 4.2	4.0	0.0001
Non-nesting	3.6 ± 3.2	7.9 ± 4.6	2.1	0.022

TABLE 4.—Distance to dune vegetation for nesting and non-nesting emergences of loggerheads and green turtles. Definition of groups is in Table 2.

	$\bar{x}$ distance (m) ± 1 SD (n)				
	Control	LPS	MV	H	P
Loggerheads					
Central					
Nesting	9.6 ± 8.0 (19)	11 ± 6.1 (15)	14.7 (1)	*0.59	0.27
Non-nesting	16 ± 7.0 (26)	18 ± 6.5 (20)	16 ± 2.5 (6)	1.5	0.48
Peripheral					
Nesting	8.5 ± 6.2 (70)	8.9 ± 6.6 (82)	8.0 ± 7.2 (58)	1.1	0.58
Non-nesting	14 ± 7.4 (80)	15 ± 7.4 (78)	15 ± 7.7 (61)	1.1	0.59
Green turtles					
Central					
Nesting	0.8 ± 3.9 (46)	0.4 ± 2.5 (23)	1.8 ± 6.0 (4)	0.04	0.98
Non-nesting	4.5 ± 7.5 (36)	3.6 ± 6.8 (24)	4.2 ± 9.9 (15)	1.2	0.54
Peripheral					
Nesting	1.6 ± 5.0 (114)	1.4 ± 4.7 (139)	2.5 ± 4.9 (141)	4.9	0.09
Non-nesting	3.1 ± 6.6 (90)	2.9 ± 5.4 (82)	4.3 ± 7.4 (96)	1.4	0.49

* A Mann-Whitney test was conducted between control and LPS groups. The statistic presented is z.

treatments in the distances of nesting and non-nesting emergences from the dune vegetation (Table 4).

All emerging turtles were able to reenter the ocean without assistance. Most turtles reentered the ocean with path deviations no more than 30° (straightness index approximately 0.8) from the most direct route. However, three green turtles and one loggerhead during MV treatment nights, and one green turtle during a LPS treatment night were misdirected after nesting. Return tracks of these turtles extended laterally toward a lighted luminaire and circled beneath it before either extending toward another luminaire or approaching the ocean. Straightness of return tracks differed among treatments in only two groups: loggerhead nesting emergences and green turtle non-nesting crawls located peripheral to the central lighted areas (Table 5).

DISCUSSION

Lighting Effects on Nesting and Non-nesting Emergences

MV lighting.—The presence of white, MV luminaires sharply reduced the numbers of green turtles and loggerheads nesting within central lighted areas (Figs. 1, 2); MV lighting also reduced numbers of non-nesting crawls within central lighted areas, although this trend was significant only for loggerheads (Table 2). For both species, MV lighting reduced densities of nesting and non-nesting crawls within centrally lighted areas as compared with peripheral areas (Table 3). Reduced nesting within centrally lighted areas during MV treatment nights was primarily due to lower numbers of turtles emerging onto the beach. This suggests that most of the decisions to abandon nesting due to the presence of MV lighting were made prior to emerging onto the dry beach. The nesting-inhibition effects at artificially lighted beaches, therefore, might not be revealed by a preponderance of non-nesting crawls. Numbers of emergences in MV treatments were too small to test statistically for differences in nesting abandonment between MV and control treatments. If increased abandonment of nesting occurred, it contributed little to reducing numbers of nests in MV treatments, because few turtles attempted nesting during MV treatments (Figs. 1, 2; Tables 2, 3).

A major component of nest-site selection by sea turtles probably involves assessments of visual cues. Although the artificial lighting of beaches is a recent phenomenon in the evolutionary history of sea turtles, it is possible that nesting on "brighter" beaches may have been selected against historically. Beaches having bleached tree trunks or exposed white sand on the dune may constitute a confusing photic envi-

TABLE 5.—Straightness indices of return paths from nesting and non-nesting emergences of loggerheads and green turtles. Indices <1.0 indicate deviations from straightness. Definition of groups is in Table 2.

	$\bar{x}$ straightness index (range; n)				
	Control	LPS	MV	H	P
Loggerheads					
Central					
Nesting	0.82 (0.26–1.0; 19)	0.77 (0.36–1.0; 15)	1.0 (1.0; 1)	*1.5	0.07
Non-nesting	0.95 (0.82–1.0; 26)	0.91 (0.70–1.0; 19)	0.82 (0.72–1.0; 6)	5.5	0.07
Peripheral					
Nesting	0.88[A] (0.55–1.0; 70)	0.77[AB] (0.20–1.0; 82)	0.64[B] (0.05–1.0; 58)	9.2	0.01
Non-nesting	0.91 (0.50–1.0; 80)	0.86 (0.25–1.0; 77)	0.90 (0.61–1.0; 61)	2.2	0.34
Green turtles					
Central					
Nesting	0.93 (0.64–1.0; 46)	0.63 (0.14–1.0; 23)	0.94 (0.80–1.0; 4)	4.9	0.08
Non-nesting	0.81 (0.24–1.0; 36)	0.84 (0.50–1.0; 24)	0.37 (0.08–1.0; 15)	1.2	0.55
Peripheral					
Nesting	0.93 (0.38–1.0; 114)	0.86 (0.17–1.0; 139)	0.81 (0.07–1.0; 141)	3.5	0.17
Non-nesting	0.92[A] (0.55–1.0; 90)	0.87[AB] (0.32–1.0; 82)	0.84[B] (0.40–1.0; 96)	6.7	0.04

* A Mann-Whitney test was conducted between control and LPS groups. The statistic presented is z.

ronment to hatchlings attempting to locate the ocean from nests. During sea-finding, hatchling green turtles (Carr, 1962) and loggerheads (Witherington, unpublished data) may become distracted by reflective objects on the beach. Artificial lighting also may misrepresent the time of day to turtles attempting to nest. Loggerheads and green turtles are nocturnal nesters. To a turtle that has not yet stranded to nest, a brightly lighted beach may signify daylight, and thus inhibit nesting.

The area of beach where MV lighting affected loggerhead and green turtle nesting was limited to the most brightly lighted portion of the beach (Figs. 1, 2). Numbers of nesting and non-nesting emergences in peripheral areas did not vary significantly among treatments (Table 2). Levels of light intensity in peripheral areas may be too low to discourage the emergence of nesting turtles.

Other broad-spectrum luminaires may affect loggerhead and green turtle nesting as MV luminaires do. Incandescent, metal halide, and conventional fluorescent lamps all emit wavelengths similar to MV lamps (Witherington, unpublished data). High pressure sodium vapor lamps are not a broad-spectrum, white source, but unlike LPS lamps, they do emit short wavelengths (Witherington and Bjorndal, 1991) that may disrupt nesting.

LPS lighting.—Light emitted by LPS luminaires had no significant effect on the numbers of green turtles and loggerheads emerging and nesting (Tables 2, 3). LPS luminaires emit light near the peak of spectral sensitivity for green turtles (Granda and O'Shea, 1972). Rather than appearing dim to turtles, LPS lighting may appear as an innocuous color to emerging turtles or as a color not interpreted as daylight. The complete spectral sensitivity of the loggerhead has not been determined.

Although I found no direct effect of LPS lighting on nesting, I am not able to rule out indirect effects that LPS lighting may have. Artificial lighting not affecting nesting turtles directly may indirectly enhance human interference on nesting beaches utilized by sea turtles. Turtles nesting in lighted areas are more conspicuous and, therefore, more likely to be approached by humans visiting the beach. Lighting in turn may make approaching humans more conspicuous to nesting turtles. The presence of humans moving within sight of a female loggerhead or green turtle prior to oviposition prompts abandonment of nesting in most instances (Witherington, unpublished data).

Lighting Effects on Nest Placement and Sea-finding

Neither MV nor LPS lighting affected placement of nests by adult females once they emerged onto the beach to nest (Table 4), the stages at which nesting behavior sequences were abandoned, or the distance traversed before nesting was abandoned (Table 4). The effect that either type of lighting had on turtles returning to the sea was small in most instances. Statistical differences in path-straightness among treatments were detected only for turtles that emerged within peripheral areas of the study beaches (Table 5). The small effect (averaged overall) that lighted luminaires had on sea-finding may only be detectable in the larger numbers of turtles emerging in the peripheral areas. Although there was little effect on seaward orientation in the majority of emergences, some individuals ($n = 5$) apparently spent a large portion of the night wandering in search of the ocean. Because misdirected female turtles may become unable to reenter the ocean due to topography, the biological effect of lighting on the sea-finding ability of nesting turtles should not be considered negligible.

Conclusions

Reduction of sea turtle nesting observed on developed beaches is explained by the effects that many types of artificial lighting have on the nest-site-selection behavior of sea turtles. Light emitted by LPS luminaires, however, had no significant effect on the numbers of turtles emerging and nesting or on their behavior. Previous work has shown that light from LPS luminaires and light of similar spectral quality have a much smaller effect on sea-finding in loggerhead and green turtle hatchlings as compared with light from other sources (Witherington and Bjorndal, 1991, in press). Given this evidence, LPS luminaires show promise as an alternative to other types of lighting on loggerhead and green turtle nesting beaches, but should be considered only as a compromise. Eliminating beach-lighting remains the most complete way to protect sea turtle hatchlings and preserve nesting on historical nesting beaches.

Resumen

Los efectos de la luz artificial en el comportamiento de las especies caguama (*Caretta caretta*) y la tortuga verde (*Chelonia mydas*) al hacer sus nidos fueron determinados experimentalmente en las playas principales de nidada: Melbourne Beach, Florida EUA (caguamas) y Tortuguero, Costa Rica (Tortugas verdes). Llevé a cabo experimentos en que una porción de cada playa de nidada permanecía oscura, o era iluminada con vapor de mercurio (MV) o con lumbreras de igual luminiscencia de vapor amarillo de sodio a baja presión (LPS). La iluminación de las playas con lumbreras MV redujo significativamente el número de tortugas verdes y caguamas saliendo y anidando dentro de las áreas de estudio iluminadas. La iluminación con lumbreras LPS no tuvo un efecto significativo en la nidada de ninguna de las especies. Algunas tortugas fueron mal dirigidas por las lumbreras encendidas (principalmente vapor de mercurio) en su regreso al océano después de sus intentos de anidar. Las lumbreras encendidas no afectaron significativamente las etapas en que los intentos de anidar fueron suspendidos ni tampoco la posición de los nidos en relación con la vegetación de las dunas. Las resultados sugieren que las lumbreras MV y otros tipos de iluminación de amplio espectro tienen el potencial de trastornar la nidada de las caguamas y las tortugas verdes. Las lumbreras LPS pueden ser una alternativa aceptable cuando la iluminación en las playas de nidada no puede ser completamente extinguida.

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