

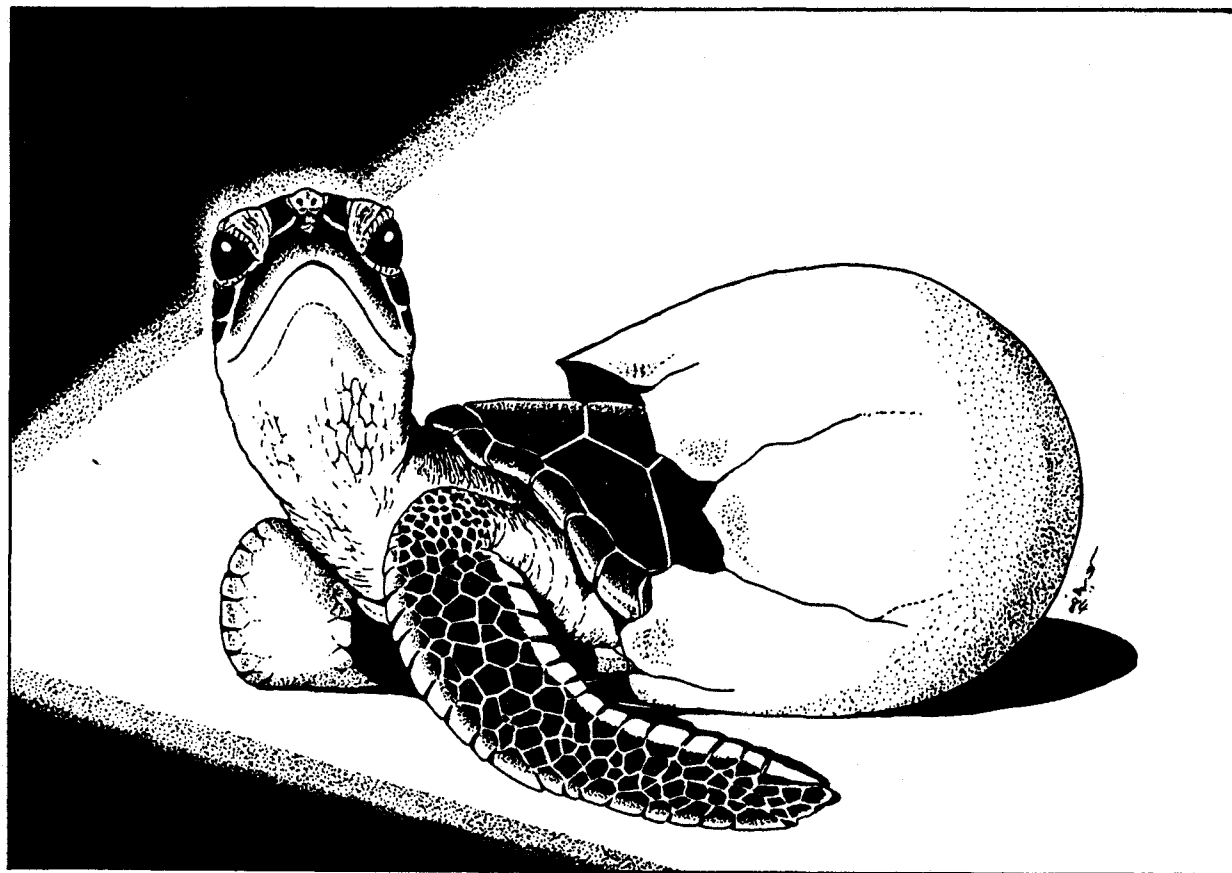
SEA TURTLE HATCHLING DISORIENTATION AND ARTIFICIAL BEACHFRONT LIGHTING

A Review of the Problem and Potential Solutions

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A Report For
The Center for Environmental Education
Sea Turtle Rescue Fund

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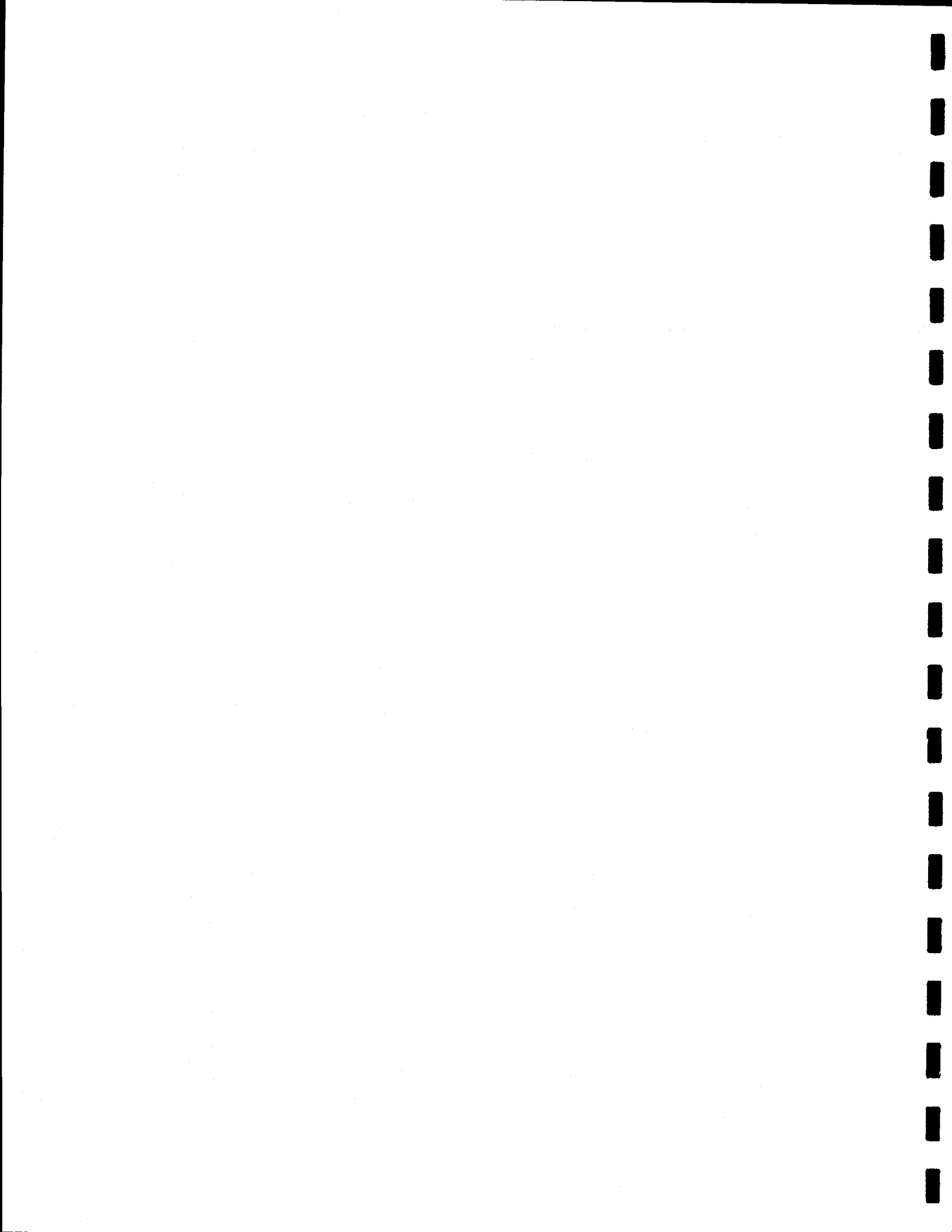


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FOREWORD

The most difficult kind of conservation is the kind that seeks to find ways for people and wildlife to co-exist so that neither suffers and, if possible, both are benefited. When this co-existence must take place on sandy ocean beaches along the southeastern American coast — some of the most rapidly developing and valuable property on earth — the task of conservation seems almost overwhelming. A final complication is introduced when we add sea turtles to the picture. Shy, vulnerable animals with inflexible behavior patterns, the nesting females are slow-moving and ponderous on land, while the tiny hatchlings are defenseless against a host of challenges ranging from predators to the heat of the morning sun.

In this pioneering report, Paul Raymond and the Center for Environmental Education have met these conservation challenges head on, demonstrating that with good science and good will it is possible for both people and sea turtles to use our beaches together. Moreover, the recommendations found in these pages achieve the ultimate goal of any conservation program, for the changes in lighting that will benefit the sea turtles will also confer economic benefits on the people who live along our shores -- not to mention the satisfaction of knowing that the sea turtles, which have been arriving every summer for so many millions of years, will still be here for us to wonder at and admire.

I hope that this comprehensive, accurate, and practical study will be widely read and adopted, and that it will serve as a model for the conservation work that still needs to be done.

David Ehrenfeld
Professor of Biology
Rutgers University

INTRODUCTION

When reviewing the scientific literature on the ocean finding ability of hatchling sea turtles, one cannot help but be impressed by the abundance and quality of the research. The hatchling's emergence from the nest and journey down the beach to the sea, although completed in a matter of minutes under natural conditions, is perhaps the most intensely studied period in the animal's life history, with the possible exception of the nesting behavior of the adult female. One of the common conclusions of these studies is that light intensity, primarily on the horizon, is the main visual cue in the orientation of hatchlings. It also has been widely accepted that bright artificial lights along nesting beaches will disorient hatchlings, causing them to spend extended periods of time wandering landward or along the beach. Such disorientation usually results in an increase in mortality and a weakening of those hatchlings that eventually do reach the sea.

Scientists are continuing to experiment on the specific details of the mechanisms of how hatchlings orient toward the sea. Reports of hatchling disorientation from artificial lights are increasing for all species of sea turtles as development increases on the world's nesting beaches. The purpose of this paper is to (1) summarize the scientific literature on the sea-finding ability of hatchlings; (2) review the documentation of hatchling disorientation caused by artificial lighting; (3) describe the types of light sources known to disorient hatchlings; and (4) propose ways in which these artificial lights can be reduced in number and modified so that they are not destructive to sea turtle hatchlings. I also discuss and evaluate past conservation measures taken in various coastal areas. I hope that this report will help encourage both the private and government sectors to implement beach lighting policies that are compatible with sea turtle conservation.

A REVIEW OF THE LITERATURE REGARDING HATCHLING ORIENTATION

The nocturnal sea-finding behavior of hatchling sea turtles has intrigued scientists at least since the early studies of Hooker (1908, 1911). The mechanism enabling hatchlings to orient properly toward the sea, even on the darkest of nights, has been intensely studied by a variety of authors. Mrosovsky (1978b) and Ehrenfeld (1979) provide excellent reviews of the abundance of papers accumulated on the water-finding ability of both sea turtles and fresh water turtles. I have summarized the literature dealing with the behavioral studies on turtle orientation in Summary I (Appendix A).

Sea turtle hatchlings almost always emerge from the nest at night. Studies by Caldwell et. al. (1959), Bustard (1967), and Mrosovsky (1968) indicate that diurnal emergence is inhibited by the heat of the day. For example, Mrosovsky (1968) concluded that underground hatchling movement in green turtles is slowed when sand surface temperatures rise above 28.5°C. The advantages of a temperature dependent nocturnal emergence are numerous: (1) lethal sand temperatures are often reached during the day on many nesting beaches; (2) predators, especially avian, are primarily diurnal; and (3) elevated daytime temperatures slow the hatchling's crawl to the sea, thus exposing the hatchlings to longer periods of predation (Mrosovsky, 1968). Daylight hatchings are usually the result of cool, often rainy weather conditions or are from nests which are shaded for much of the day.

Geotaxic orientation (i.e., the taking up of a direction in relation to the slope of the beach) was hypothesized as the primary mechanism for hatchling orientation in the early works of Parker (1922) with loggerhead turtles, and in those of Noble and Breslau (1938) with fresh water turtles. These authors failed to account for the fact that on many beaches the tendency to move downhill would not result in the hatchlings finding the surf. Nests are often located in such a way that the hatchlings would have to crawl upward before reaching the downward slope to the water. Geotaxic orientation has since been shown to play a minimal role, if any at all, in the ocean finding behavior of sea turtles (Hendrickson, 1958; Carr and Ogren, 1960; Ehrenfeld and Carr, 1967; Ehrenfeld, 1968; Mrosovsky and Shettleworth, 1968, 1974).

The evidence strongly indicates that sea turtle orientation depends largely on a visual response to light. When hatchlings were blindfolded, they wandered in a confused and aimless manner, whether on a sloped beach or not (Daniel and Smith, 1947; Carr and Ogren, 1960; Ehrenfeld and Carr, 1967). These blindfold studies and an experiment by Carr and Ogren (1960) have also demonstrated that the mechanism for orientation is not simply a genetically imprinted compass sense. Green turtle hatchlings, hatched on

the east coast of Costa Rica, were taken to the Pacific side and were able to orient toward the water immediately. They accomplished this in spite of the fact that the compass direction they took was opposite the direction they would have taken had they been released on their native shore. Thus, compass sense does not appear to be a factor in the hatchlings' ability to locate the sea, though it may later be involved in the navigational ability of the adults during migrations.

Daniel and Smith (1947a, 1947b) conducted experiments in both the lab and field on loggerhead turtles, and concluded that natural seaward light was the critical stimulus that orients a hatchling toward the ocean. This light over the open water provides an effective stimulus even when the ocean is hidden by dunes or other structures under natural conditions. The relationship between light intensity and the topography of the horizon has been emphasized by many authors as being the predominant factor in ocean finding behavior (Ehrenfeld and Carr, 1967; Limpus, 1971; Mrosovsky, 1972; Verheijen and Wildschut, 1973). The difference in light intensities between the seaward and landward directions occurs mainly at the respective horizons and the hatchlings are able to accurately discriminate between these light intensities under natural beach conditions.

Although vision is essential for orientation on land, especially for the discrimination between light intensities, it has been established that sea turtles are very myopic (near-sighted) when their eyes are out of water (Ehrenfeld and Koch, 1967). Therefore, the orientation of sea turtles is not dependent on sharp, clear retinal images. This was substantiated by an experiment in which adult green turtles were fitted with spectacles containing filters that blurred their vision. These filters failed to impair orientation (Ehrenfeld and Carr, 1967). Visual acuity, anatomical, and physiological studies on turtles are summarized in Summary II.

Turtles, in general, have both photopic (daylight vision) and scotopic (night vision) mechanisms, as well as the ability to discriminate color and brightness (Walls, 1942; Quaranta, 1952; Armington, 1954). In the eye of the green turtle, cones predominate and rods are few. Oil globules which are usually associated with the cones are not organized in any discernible pattern and provide further evidence that the eye is more suited to the marine environment than to the air (Granda and Haden, 1970).

Recently, scientists have examined the details of the mechanisms that orient hatchlings. Once it was established that light was the primary cue, experiments were conducted to determine what qualities of light were most responsible for stimulating hatchling orientation. Hooker (1911) and Parker (1922) stated that sea turtle hatchlings were attracted to "blue light" from the ocean and that this was the stimulus to initiate orientation. Mrosovsky and Carr (1967) examined this color preference and concluded that hatchlings did indeed demonstrate a preference for the shorter wavelengths of blue and green, as compared to red, if given a choice between the two. Research by Ehrenfeld and Carr (1967) and by Mrosovsky and Shettleworth (1968), also demonstrated that hatchlings preferred blue light over red, but warned that this was probably a response to brightness rather than a response to the color hues. In other words, the shorter wavelength light

(blues and greens) seemed brighter to the hatchlings. Color filter experiments have shown that blue light is not necessary for sea finding orientation and that the stimulus for orienting toward the water is primarily based on light intensity, rather than color discrimination (Ehrenfeld and Carr, 1967; Ehrenfeld, 1968). Verheijen and Wildschut (1973) have further stated that it is unlikely that hatchlings can even discriminate color at night under conditions of low illumination.

In summarizing the water finding ability of hatchling sea turtles, it can be said that they react "tropotactically to light"; that is, they compare the light intensities at the horizon level and balance the brightness inputs entering both eyes, enabling them to maintain an orientation toward the light from an open horizon (Ehrenfeld, 1968; Mrosovsky, 1972). Under most natural beach conditions, this light is in the direction of the sea and away from the darker dune masses and landward vegetation. However, landward artificial bright lights can reverse this.

Mrosovsky (1970) states that any type of visual light stimulus will have some effect on hatchling orientation. Artificial lights introduced on the landward horizon can lead to hatchlings orienting in the wrong direction if the illumination has a greater intensity than the seaward horizon. Hendrickson (1958) noted that green turtle hatchlings could be "guided at will" up and down the beach with a flashlight. Ehrenfeld (pers. comm.) fitted adult green turtles with masks containing a light source over each eye. By independently varying the brightness of these lights, he could control the direction of movement of the turtles: they would turn toward the side of the eye that was receiving the bright illumination.

In southeastern Florida, McFarlane (1963) documented that artificial road lighting provided a strong enough stimulus to overcome the natural phototaxis involved in orientation. Because of the bright streetlights, hatchlings were found disoriented on the highways that were parallel to the beaches. Hatchling disorientation was also observed and documented by Philibosian (1976) for hawksbill turtles in the U.S. Virgin Islands and by Mann (1977), Fletemeyer (1979a), and Bandre and MackMakin (1983) for loggerhead turtles in Florida.

Mann (1977) studied six southeast Florida beaches and documented the quantity of artificial lighting present on each. He then documented disorientation on those beaches by determining the directional bearings that the hatchlings took upon emergence from their nests. His results clearly demonstrated a landward orientation taken by those hatchlings on beaches with intense beachfront illumination. Table 1 (Appendix B) contains a brief summary of these findings (Mann, 1977). Mann (1977) also described the paths taken by disoriented hatchlings on the beach. He stated that hatchlings would often crawl past the original light that attracted them, only to continue in the direction of other light sources.

Under natural conditions, hatchling sea turtles will maintain a consistent offshore bearing once in the water (Frick, 1976). This behavior, however, can be disrupted by bright landward lights. Moorehouse (1933) was able to draw hatchlings back onto the beach by shining a bright light in

the surf. Similarly, Carr and Ogren (1960) reported that an intense artificial light (a kerosene lamp in this case) could override the natural orientation and draw hatchlings out of the ocean. Fletemeyer (1979a) conducted a variety of experiments to test whether hatchlings were disoriented by coastal lights after entering the sea. He concluded that hatchlings were initially disoriented by the lights, but would eventually orient properly due to the swimming response against the wave direction.

Mortality of disoriented hatchlings is due to a variety of factors. In many cases, hatchlings are simply lost in the dune vegetation and succumb to the heat and dehydration of the following day. Mann (1977) found hatchlings that were randomly crawling on the beach during the day with their eyelids dried shut. Hatchlings that remain on the beach may orient correctly once daylight arrives, but high temperatures (above 24°C) can weaken the hatchlings' response to all stimuli, thus inhibiting activity (Mrosovsky and Shettleworth, 1968).

Obviously, any hatchling disorientation increases the exposure time to predators. The predators of hatchlings are quite numerous if diurnal species are included (Hirth, 1971). Predation by fish during the early morning hours is greater than at night (Mann, 1977; Limpus, 1978). Birds such as gulls, frigate birds and vultures are known to prey on stranded live hatchlings (Mrosovsky, 1971; Bustard, 1973). Crabs, particularly ghost crabs (*Ocypode* sp.), are perhaps the most efficient nocturnal predators of hatchling sea turtles. The extended period of time spent on the beach by disoriented hatchlings allows ghost crabs greater opportunity to capture them (Bandre and MackMakin, 1983). Numerous dead hatchlings have been retrieved from crab burrows in the vicinity of bright beachfront streetlights (Figure 1, Appendix C). Other potential predators on wandering hatchlings in the southeast United States include feral cats, dogs, and raccoons. Those hatchlings that eventually find the sea after spending an extended period of time on the beach are undoubtedly weaker and their chances of survival during the first few days are diminished.

HATCHLING DISORIENTATION: A WORLDWIDE PROBLEM

Fortunately, many of the world's largest sea turtle rookeries are located in the undeveloped tropical regions where coastal lights have yet to be introduced. However, as these regions "grow" disorientation of hatchlings by artificial lights will become an increasing problem.

On Heron Island, Australia, a major loggerhead and green turtle rookery, resorts and their coastal lights have made hatchling disorientation a common occurrence (Limpus, 1978). In his chapter entitled "The Reef" in Exploitation North: Australia's Wildlife from Desert to Reef, Limpus (1978) states "...resort staff have gathered hatchlings from around the buildings in rubbish bins such were the numbers. While this may be entertaining to tourists, it is quite disastrous for the turtles."

In the Hawaiian Islands, most (90%) nesting by green turtles is on French Frigate Shoals, which is in the Hawaiian Islands National Wildlife Refuge. Consequently, these islands are largely uninhabited, but artificial lights at government facilities on East Island and Tern Island have regularly disoriented hatchlings (Balazs, 1980). On the main Hawaiian Islands, where hawksbill turtles nest on a few scattered beaches, light disorientation is a problem on several developed shorelines (Balazs, pers. comm.).

Misirah Island in the sultanate of Oman has, perhaps, the largest nesting population of loggerheads in the world (estimated at 30,000 nests a year). The town on the main nesting beach has rapidly developed and incidences of light-induced hatchling disorientation have increased (Ross and Barwani, 1982).

At Ascension Island, which is the nesting ground for an isolated and unique population of green turtles, coastal activity and its associated lights have drawn emerging hatchlings away from the sea (Mortimer, 1979; Mortimer, 1982). Mortimer (1979) warns of the disastrous effects that commercial development would have on this green turtle population if proposed resorts were built on the small concentrated nesting beaches.

Hatchling disorientation has also been documented in Sabah, a state in East Malaysia (de Silva, 1982); Ohama Beach, Japan (untranslated author); the Lesser Antilles (Meylan, pers. comm.); and the island of Canton, which is part of the Phoenix Islands in the Pacific Ocean (Balazs, 1982).

There are few accounts published in the scientific literature documenting the occurrence of hatchlings disoriented by beachfront lighting in the United States (McFarlane, 1963; Philibosian, 1976; Mann, 1978). However, virtually every sea turtle field biologist and many concerned beach residents can expound upon the frequency of its occurrence every nesting season.

The southeastern coast of the United States is the major nesting ground for the western Atlantic population of loggerhead sea turtles, with 90% of nesting occurring in Florida and the remainder in Georgia, South Carolina, and North Carolina. Fortunately, much of the nesting in South Carolina and Georgia occurs on isolated islands, under state or federal ownership. However, some nesting beaches such as Fripp Island and Kiawah Island in South Carolina are privately owned and resorts, boardwalks, and further beachfront lighting pose a potential problem for these hatchlings (Hopkins, pers. comm.). Several cases of hatchling disorientation and mortality have also been documented at Edisto Island in South Carolina (Mundell, 1983).

Florida's east coast for the most part is vastly developed, with the few remaining coastal areas earmarked for future development. The beaches of south Brevard County (449 nests/km), Hutchinson Island (112 nests/km) and Jupiter Island-Hobe Sound (182 nests/km) are experiencing rapid shoreline development (Hopkins and Richardson, 1981). Hatchling disorientation has subsequently increased on these important rookeries (Ehrhart, 1983; Witham, pers. comm.; Martin, pers. comm.). On the brightly lit and developed beaches of Broward County in south Florida, hatchlings are seldom successful in their attempts to find the sea (Fletemeyer, 1980).

Hatchling disorientation is also becoming more of a problem in Puerto Rico and the Virgin Islands (Rainey, 1978; Towle, 1978; Boulon, pers. comm.). On St. Croix, leatherback hatchlings are frequently attracted to the artificial lights of resorts (Meylan, pers. comm.). Unfortunately, development on beaches appears unavoidable; therefore, management practices that would reduce artificial lighting to tolerable levels are greatly needed.

DESCRIPTION OF PROBLEM LIGHT SOURCES

Beachfront Building Lights

Building lights, as discussed here, mainly refer to outdoor area light fixtures that are common on beachfront condominiums, restaurants, beach homes, etc. These lights are responsible for much of the hatchling disorientation because they can direct an intense light out over the dune and onto the beach. The purpose for beachfront building lights are various. They may be used for: (1) security and/or safety, (2) decorative and landscape illumination, (3) recreational activities, and (4) undetermined reasons (Figure 2).

Floodlight or spotlight fixtures are particularly detrimental to hatchlings because they frequently are located on the roofs of condominiums and other beach structures and illuminate large sections of beach (Figure 3). Floodlights discharge high intensity light from incandescent, fluorescent, mercury vapor, or high pressure sodium lamps. Other lights associated with beachfront buildings include surface wall mount fixtures and landscape lantern posts. Post lantern lights are primarily incandescent and are popular in illuminating private dune crossovers and walkways. Wall mount fixtures are often used on balconies to illuminate porches or patios. While light intensities of these fixtures are usually low, in beach resort areas they often are quite numerous and can significantly brighten the landward horizon (Figure 4).

Streetlights and Similar Public Light Fixtures

McFarlane (1963) documented numerous incidences of hatchling disorientation caused by streetlights located along highway AIA in south Florida. In one nest, 95% of the hatchlings oriented toward the road and many were crushed by passing automobiles. Fletemeyer (1979a) also investigated many dead loggerhead hatchlings along a half-mile section of AIA in Ft. Lauderdale and concluded that streetlights running along the shoreline were responsible for the disorientation. Streetlights, either mercury vapor or high pressure sodium, discharge light at a high intensity and are frequently located adjacent to a beach; therefore, they are one of the primary sources for disorientation (Figure 5). To make matters worse, virtually all these lights are equipped with photoelectric cells and operate from dusk till dawn.

Single streetlights are often situated out on the primary dune, and are used to illuminate public beach access areas (Figure 6). Because of the direct brightness of these lights and the proximity to the beach, hatchlings from nests located over a hundred yards away can be affected (Bandre and MackMakin, 1983). Beach boardwalks, public parks, and resort areas also maintain streetlights to illuminate their parking lots (Figure 7A and 7B). These bright multiple lights can attract hatchlings landward, over the dune, and into the parking areas where many are killed. Those that survive until daylight often reorient correctly but are unable to reach the ocean if a curb is present (Bandre and MackMakin, 1983).

Vehicular Lights

Automobile lights generally do not pose as great a threat to hatchlings as the bright stationary lights mentioned previously. The light from coastal traffic, with some exceptions, is blocked by dune and other beach structures. There are, however, many coastal areas that still allow vehicles to drive on the beach (e.g., Amelia Island and Daytona Beach) and the direct glare of headlights would certainly prevent hatchlings from taking the shortest route to the sea. In some poorly planned coastal areas, recreational vehicles are allowed to camp directly on or near the beach. Even sea turtle survey patrols that utilize all-terrain motorcycles can disorient hatchlings if low intensity lights aren't used.

Flashlights

The time of hatchling emergence frequently coincides with the time beach walkers are scouring the beach with flashlights. A bright torch or flashlight can attract hatchling sea turtles, even after they have entered the surf. Although with good intentions, but not realizing that their lights are the cause of the problem, people often collect the wandering and confused hatchlings for release into the surf. Hatchlings can spend quite an extended period of time "being led" along the beach by flashlights owned by curious, but unknowing beachcombers. Torches and lanterns from surf fishermen have also been known to disorient hatchlings.

Miscellaneous Problem Light Sources

Several authors have pointed out the need for further research to determine whether hatchlings are disoriented by offshore artificial lights. deSilva (1982) documented that brightly lit fishing boats, anchored off Turtle Islands National Park in East Malaysia, attracted and disoriented a large number of hatchling sea turtles. Many of these hatchlings were subsequently eaten by predatory fish that were also attracted to the lights and activities of the boats. In Hawaii, ships with bright deck lights that were anchored several miles offshore attracted dozens of hatchlings (Balazs, pers. comm.). Mann (1977) indicated that a fishing pier in Pompano Beach, Florida lured newly-hatched loggerheads to its lights and discussed increased predation of hatchlings under these circumstances. It seems likely that brightly lit offshore oil rig platforms also attract hatchlings in the vicinity.

There is quite a diversity in the types of shorelight that affect turtles by altering the natural brightness of the horizon at night. Campfires, which are popular on many beaches, can have obvious disastrous effects on emerging hatchlings. For example, Mortimer (1979) found over 500 charred green turtle hatchlings in an unattended bonfire on Ascension Island. In the U.S. Virgin Islands, hawksbill hatchlings were attracted to stadium lights during a baseball game; this resulted in many of these hatchlings being crushed on nearby roads (Philibosian, 1976). Another source of concern are beachfront buildings that are under construction, for they are usually brightly lit for security reasons.

Well lighted launch pads at Cape Canaveral and a nuclear power plant on Hutchinson Island have not been known to cause hatchling disorientation (Ehrhart, 1979; Wilcox, pers. comm.). However, if further illumination occurs on these structures, there could be a serious orientation problem for sea turtles at these two major nesting locations.

The effects on hatchlings by the overall illumination of reflected light from a city is uninvestigated. Mann (1977) states that the artificial light sources primarily responsible for hatchling disorientation are those that shine directly on the dune and are visible from the nest site. This conclusion has been inferred by most sea turtle biologists. Therefore, reducing lighting that shines directly on beachfront property should be the primary focus for management practices on developed beaches. Any future coastal developments should be designed in such a way that lights are not present or not visible from the beach.

POTENTIAL SOLUTIONS

Eliminating the Light Sources

The most effective solution to the hatchling disorientation problem is to eliminate or reduce problem lights. In many cases, turning off beachfront lights can be easily accomplished once owners (i.e. whoever is paying the bill: resident, municipality, condo association, etc.) are informed of the situation. This is also an economical solution as costs for operating high intensity outdoor lights are rather high.

Table 2 provides a lighting guide chart that compares the yearly operating costs for incandescent light and three high intensity discharge light sources (mercury vapor, metal halide, and high pressure sodium). The total yearly operating cost to light a typical industrial area with 500 W incandescent light is in excess of \$2,800. High intensity discharge (HID) lamps are more efficient, but operating costs are still considerable: mercury vapor = \$1,000; metal halide = \$750; sodium = \$490. These HID light fixtures are becoming more popular along beaches because they use less energy to provide similar bright light levels (Wilcox, pers. comm.).

Frequently, bright outdoor area lights are excessive in number and often are not practical for the job conditions. Many light sources allow large amounts of light to escape into unwanted areas. This misdirected glare is not only wasteful, but can be highly detrimental to the emerging hatchlings. Some artificial coastal lights seem to serve no function at all, yet are left on the entire night.

Elimination of light sources can be divided into three categories: (1) year-round elimination, (2) seasonal elimination, and (3) nightly elimination. Eliminating existing shoreline lights for the entire year is preferable because management practices and light reduction measures would not have to be initiated every nesting season. The process of eliminating specific problem lights seasonally can be time consuming and early nests can hatch before such efforts are made. Year-round elimination is also the most economical, both in operating costs and in on/off fees. On the few undeveloped nesting beaches, a proper coastal management plan should prohibit the growth and year-round use of all beachfront lights.

Seasonal restrictions on the use of beachfront lights should begin before the beginning of the nesting season and continue through the hatching season. Therefore, in the southeast United States, the dates of shutoff are late April to late October (based on a nesting season that begins on approximately 1 May and ends approximately 31 August, with an incubation period of 50-60 days). Caution should be taken so that lights are not inadvertently turned back on when adult nesting activity stops.

Nightly restrictions can be utilized for those lights that cannot be turned off for safety reasons or because of nightly public activity. These lights could be placed on automatic timers that are pre-set to go off at a

time when public activity ceases. A suggested time for shutoff is midnight. This would allow those hatchlings that were originally attracted to the artificial lights the opportunity to reorient correctly. Although not an ideal solution, timer-adapted lights could prevent endless hours of wandering and reduce the hatchling mortality that occurs due to exposure to daytime temperatures. This would mean that many outdoor area lights already equipped with photoelectric cells (on from dusk to dawn) would have to be converted to on/off timers, or a combination of the two. The costs of these conversions would be defrayed by savings on electric bills. If nightly restrictions are chosen as a management option, it would be best to also modify such lights in other ways, so that their impact on hatchlings is further minimized.

Preventing Direct Light From Being Cast on the Beach

(A) Shading or Screening the Existing Light Sources

Those beachfront lights which cannot or will not be turned off may be modified to include shades or screens. If positioned correctly, this would prohibit direct light from being cast over the dune and onto the beach. Hatchlings that are shaded from a direct light source are often able to orient toward the open seaward horizon (Mann, 1977).

After consulting with various light manufacturers, power companies and electrical contractors, I have concluded that specific shades/shields are not commercially available for common outdoor beachfront lights. However, a variety of shading and screening devices can be custom fit to many existing light fixtures. These would be inexpensive and could be effective in reducing stray illumination on the beach. For instance, streetlights could be fit with mushroom-type shades or rigged with metal shields that reflect the light (Figure 8). Smaller landscape lights, frequently used to illuminate shrubbery and walkways, can be equipped with tier-type shades that encircle the lamps so that light is directed downward where it is needed most. Wall mount light fixtures can be fitted with hoods that allow light to escape in only one direction (Figure 9). These covered lights are preferred if low level illumination is needed on balconies and porches as long as the redirected light is then shielded from the beach by the dune or vegetation.

Post and coach lantern fixtures that contain several lens panels (often four, forming a square) can be altered so that the panel(s) facing the ocean are blackened or screened. Partially painting a clear lens black or even covering it with aluminum foil can reduce the illumination. Fine-mesh metal screens, lining the lenses of large "cobrahead" streetlights would also reduce some light intensity. Dark background surfaces are also preferred on beach structures as they would absorb light and help eliminate excess reflected light from illuminating the landward horizon. It would also be helpful if all ocean facing windows in resorts and condominiums were tinted to reduce inside glare or shades were drawn during the nesting season.

(B) Using Natural or Structural Barriers to Block the Light Source

Natural barriers, such as thick vegetation, could be placed between a light source and the beach to prevent direct light from illuminating nest sites. Australian pine, which is an exotic species in the United States and one of the few large trees capable of growing near the ocean, have been used at Hutchinson Island to block coastal lights (Wilcox, pers. comm.). However, native tree species are preferred. Any structural barriers, such as drift fences, that shield the landward illumination would be beneficial.

(C) Lowering the Elevation of the Light Source

Shoreline lights, if they have to be maintained, should be set at as low an elevation as possible. However, this applies only in those cases where a dune system, vegetation, or structures are present that would block the lowered light. When hidden behind dunes or natural vegetation, light is usually not significant enough to attract hatchlings. The lower the mounting height of the light source, the smaller the illumination area. Figure 10 shows several examples of low profile lamps that are appropriate for illuminating beach walkways, parking lots, and other safety areas. These light sources are below eye level and provide sufficient lighting for these areas. Security lights at construction sites should also be placed low to prevent direct light from spilling out onto the beach.

(D) Replacing Existing Lights with Modern Alternative Lights

Alternative lights should be considered only when lighting is unavoidable and mandatory. Because of modern "light trespass" laws that have been implemented in some parts of the country, light fixtures (recently termed "luminaires") have been developed that eliminate unwanted light and high angle brightness. There are even high intensity discharge luminaires suitable for roads and parking lots. These concentrate the light in the needed areas, yet prevent it from spilling over the property line.

An example of this type of light is provided in Figure 11 (Crouse-Hinds, CLX Precise Light). The reflector design is engineered to cut off light at a designated angle; in this particular case the extremity of the beam is cut off at 73 degrees. A more important feature is that it provides a lower cut-off angle of 3 degrees, which would virtually eliminate light cast behind the pole. If positioned and mounted properly with the light directed away from the beach, this type of luminaire would be a considerable improvement over those currently being used along AIA and other coastal roads. These lights can be adapted with accessory timers and can be automatically turned off after three to seven hours of operation.

Wall mount light fixtures are also available with a sharp-angle cut-off system which helps eliminate glare and light spillover. Figure 12 compares a modern luminaire (a Paracyl Light from Moldcast Lighting) with both a floodlight and a prismatic wall mount. The floodlight and prismatic

would be unacceptable in beachfront areas because they allow light to escape at high angles, causing it to be cast over the dune. A sharp cut-off angle should be positioned so that the back side of the dune blocks any excess light. There are many modern low-profile luminaires available for lighting walkways. Some have multiple reflectors that redirect light downward from a concealed hooded lamp, yet still provide sufficient illumination (Figure 10).

Modifying the Intensity and Wavelength of Light Emitted

I have previously discussed how sea turtles demonstrate a preference for blues and greens (shorter wavelengths) over reds, when given a two-choice situation (Mrosovsky and Carr, 1967). However, it is extremely important to remember that controlling the brightness factor is critical when trying to determine if hatchlings can discriminate wavelengths. It was concluded that hatchlings are primarily controlled by brightness and that color per se does not play a significant role in orientation (Ehrenfeld and Carr, 1967; Ehrenfeld, 1968; Mrosovsky and Shettleworth, 1968). A red lens that would reduce the intensity of the short wavelength light that turtles can see would, however, be preferable to a clear lens. Nevertheless, before recommending red filters as a solution to the disorientation problem, I feel that further applied research needs to be conducted to determine the color characteristics of filters that will do the job. For example, hatchlings that may not be able to see "red" light above 610 nm (nanometers), may be able to detect and be distracted by "red" light above 590 nm (Ehrenfeld, pers. comm.). A misleading and dangerous precedent could be initiated if reddish lights were utilized by developers as a "cure" for hatchling disorientation.

Reducing the power at the source would obviously also help in the lowering of the light intensity. Unfortunately, this does not appear to be an option when dealing with the large "all or none" mercury vapor and high pressure sodium streetlamps. Incandescent-type light fixtures usually allow easy access to the bulbs; therefore, they can be changed to reduce the wattage and brightness.

Summary of Potential Solutions

The following outline summarizes the solutions previously discussed. It must be emphasized that these recommendations are primarily for existing lights in developed areas. Any future coastal development should be designed in such a way that lights are not present or visible on the beachfront side.

- I. Eliminate the Light
 - A. Year-round elimination
 - B. Seasonal elimination
 - C. Nightly elimination (timers)

II. Prevent Direct Light on Beach

- A. Shade or screen the existing light
- B. Use natural or structural barriers to block the light
- C. Lower the elevation of the light
- D. Replace existing lights with modern alternative lights

III. Reduce the Intensity of the Light

PAST PREVENTIVE MEASURES TAKEN

The hatchling disorientation problem appears to be increasing as more of the world's nesting beaches are developed and more horizons are altered by artificial lights. However, there have been efforts to minimize beachfront lighting in Japan, Australia, and the southeast United States.

In Ohama Beach, Japan, where sea turtle nesting had declined steadily for years, the beach was closed to the general public from 1 June to 31 August. Ocean front hotels were required to reduce their lighting and even the coastal road was closed from 8 p.m. to 4 a.m. so that streetlights could be shut off.

In Australia, with the help of the Queensland National Parks and Wildlife Service, efforts are being made to inform tourists and beach residents about the effects of lights on turtles. In the 1981 hatching season on Heron Island, considerably fewer hatchlings were found wandering among the resorts than in previous years (Limpus, et. al., 1981). This was attributed to a public awareness campaign that utilized posters, stickers, and a brochure that requested coastal buildings to eliminate excess lighting (Figure 13).

Along the beaches of the southeastern United States, several effective light reduction programs have been undertaken by concerned private beach residents and local volunteers. Each year thousands of the Center for Environmental Education's "Attention Beach Users" brochures, which addresses this issue, are distributed at National Seashores and Refuges and at coastal developments (Figure 14). In South Carolina and Georgia, members from the sea turtle carcass stranding networks have initiated efforts to reduce lights from beach developments (Hopkins, pers. comm.). At Kiawah Island, South Carolina, light structures have been specifically modified to prevent light from being directed onto the beach. Homeowners are given guidelines in an Environmental Inventory Statement that restrict certain types of fixtures, such as floodlights, from being used on the beach (Kriet, pers. comm.). Volunteers send out letters every nesting season to inform owners and renters about the effects of excess illumination at both Kiawah and Fripp Islands. At Edisto Island in South Carolina, a "lights off" campaign was endorsed by the Town Council of Edisto Beach and several problem lights were shielded. A letter also was distributed to all beachfront residents notifying them of the hatchling disorientation problem.

The efforts of concerned "turtle people" in various coastal communities in Florida (e.g., Hutchinson Island, Juno Beach, Ft. Lauderdale, etc.) have also contributed to the reduction of beachfront lighting. A document entitled "Hutchinson Island Resource Planning and Management Plan," which was approved by the state of Florida in 1983, specifies various sea turtle

protection measures (Figure 15). The plan outlines several light restriction policies that are to be incorporated in the design and construction of beach development on Hutchinson Island. The effectiveness of such a document has yet to be determined. The responsibility to implement and enforce the light restrictions is given to the local municipalities on the island.

The town of Palm Beach has also shown interest in adopting a coastal management plan that would include light restrictions during the nesting season (Witham, pers. comm.).

On the brightly-lit shorelines of south Florida sea turtles and development are frequently not compatible (Fletemeyer, 1979b). As a consequence, hatcheries are maintained in order to collect and release hatchlings in darker sections along the coast.

In the city of Boca Raton, which has a five mile shoreline, measures have been taken to minimize the effects of lights on sea turtles (Wolf, pers. comm.). The city's ocean parks (2.5 miles of beach) have dim, low-profile lights installed on the public walkways and timers are adapted to the fluorescent lights on the pavilions. The city government also informs new developments of the potential problems of beachfront lighting.

In south Brevard County, Florida, which has one of the highest nesting densities in the country, averaging approximately 450 nests/km, hatchling disorientation is a recent and potentially disastrous problem. Undeveloped shorelines are rapidly becoming beaches with brightly lit resorts and condominiums. With such high nest densities, a single floodlight located above the dune can disorient several thousand hatchlings in a season. Literally hundreds of thousands of loggerhead hatchlings could be killed as a result of artificial illumination in a 30 km section of beach extending from Indialantic to Sebastian Inlet (Ehrhart, 1983). In 1982, several newspaper articles were published in the local Brevard paper addressing the hatchling disorientation problem (Figure 16). Specific offensive light sources at various motels, condominiums, and public sites were identified. Within days of the newspaper articles significant lighting reductions occurred throughout the coastal towns in Brevard County. The concerns of local residents, once aware of the situation, and the fear of "bad press" elicited immediate action by many local governments and beach developments. South Brevard County is continuing to expand its shoreline illumination at a rapid pace as more growth occurs. Currently, no lighting restrictions are required for any beach structures in the county; however, the Planning and Zoning Department has drafted a letter to be distributed to beachfront owners requesting light reductions (Figure 17).

RECOMMENDED RESEARCH

Further scientific research to determine what cues are involved in the orientation of hatchling sea turtles is not needed currently, at least not when addressing the problem of hatchling disorientation by artificial lights. It has been well established in a series of excellent publications by a number of authors that hatchlings orient primarily by a tropotactic reaction to light (see Summary I). However, there does appear to be a need for applied research to determine what light intensities and light wavelengths will not interfere with hatchling orientation. For example, how many footcandles of illumination from various kinds of sources placed on the dune are required to attract hatchlings toward it? Such a study would need to be conducted under beach conditions and would have to take into consideration the varying natural elements (e.g., full moon, no moon, cloudy night). There is also a need for further research in the development of light shields and screens, in order to reduce the illumination from beach lights that cannot be turned off. Since shields and shades are not commercially available for the majority of existing lights, it is necessary to determine what shading designs are the most effective and practical for particular light sources. Once developed and installed, these shaded lights should be evaluated for their effectiveness.

A thorough study of the effectiveness of all of the potential solutions discussed in this report should be undertaken. This is of primary importance and could be accomplished in two ways: (1) a so-called experimental design test and (2) an applied test. The experimental test would be designed to accumulate quantitative data on hatchling disorientation for pre-solution and post-solution periods. In other words, various light structures, representing the known problem light sources, would be established in different study areas. Incandescent, mercury vapor, and high pressure sodium lights should all be represented. The study should control for intensity and spectral distribution of the light output. These lights would be monitored for an extended period of time (e.g. half the hatching season) and information collected on the number of hatchlings disoriented, distance from the light source to the nest, environmental conditions at the time of hatchling emergence, etc. Then the various lights would be shielded, eliminated, lowered, etc. and data collected for the second half of the season in order to evaluate the solutions attempted. A relatively equal sample of nests would be used for each type of problem light and for both the pre-solution and post-solution periods. This would probably require the relocation of nests to the various study sites containing the different lights. Such a systematic design would have to be conducted on a non-public beach where extraneous lighting was not a problem. It would, however, lend invaluable data to many aspects of the hatchling disorientation problem.

The second evaluation method, the applied test, would utilize already existing beach lights that have been known to disorient hatchlings in the past. After quantifying this disorientation, these problem lights would be modified with several of the techniques available and rechecked for their disorienting effect.

There are many lights that are known to be a problem, but to what degree is usually unknown. It would be useful to know how many hatchlings are disoriented by specific lights throughout a hatching season. This can best be found out by experienced turtle watch groups and turtle nesting survey crews. It is recommended that these groups make written observations of hatchling crawls, particularly in areas that are illuminated. This would not only target these lights as being detrimental to hatchlings, but would provide initial data for the applied test described above.

The effects of offshore lighting on hatchlings has been documented by several authors, but the frequency and impact of these occurrences is relatively unknown. In addition, little is known on the behavior of hatchlings once they enter the ocean. How coastal lights affect their swimming and drifting behavior requires additional research. Unfortunately, such a research project would be difficult and expensive.

It is questionable whether stationary beachfront lights affect adult nesting females and their distribution along the coast. Mann (1977), in his work in south Florida, concluded that nesting females, both green turtles and loggerheads, did not avoid the well-lit beaches in favor of darker, undeveloped beaches. At Hutchinson Island, William-Walls, et. al. (1983) reported that the nesting distribution did not significantly decrease in areas where development occurred. However, Mortimer (1982), working with green turtles at Ascension Island documented the decline in nesting females on beaches that were artificially illuminated, even when the lights were not directly visible on the beach. Adult green turtles were also found to avoid bright areas on nesting beaches in Costa Rica and Florida (Carr et. al., 1978; Ehrhart, 1979). Raymond (1984) indicated that adult loggerhead emergence patterns were correlated with variations in beach front lighting in south Brevard County, Florida. Nesting females avoided areas where beachfront lights were the most intense. Similar findings were reported by Fletemeyer (1979a) and Bandre and MackMakin (1983). Additional research appears warranted for long-term studies of nest distribution in those areas that are undergoing rapid development.

RECOMMENDED STRATEGY

To solve or minimize the problem of hatchling disorientation caused by artificial beachfront lighting, one must consider and incorporate several of the topics discussed in this report. Recommendations can be divided into four areas:

1. Identify the existing problem lights and eliminate or modify them;
2. set guidelines and standards for acceptable beachfront illumination;
3. establish coastal lighting ordinances that restrict shoreline lighting; and
4. educate the public in coastal areas concerning the problem of hatchling disorientation.

1. Table 3 identifies the major types of problem lights that occur along the beaches of the southeastern United States. In most cases several potential solutions are provided for each kind of light identified. The recommended solutions are not the only ones available, and it is hoped that these suggestions will stimulate other solutions.

2. It is recommended that an active exchange of ideas and information take place between sea turtle biologists, electrical engineers, lighting contractors, and local government representatives to develop accurate guidelines and standards for tolerable light levels. A conference specifically addressing beachfront lighting could be held in the southeast United States. Such a meeting could sensitize developers and planners to the light problem and should focus on the development and implementation of a model ordinance. Once acceptable and practical standards for beachfront lighting are determined, they should be adopted by the various levels of state and local governments.

3. Beachfront light restrictions should be included in area coastal resource and management plans. Such ordinances should require specific regulations that prohibit the use of lighting known to cause hatchling disorientation. It is recommended that enforcement responsibilities be given to local governments in consultation with state and county authorities and that penalties be assessed for lighting violations. Coastal developers when applying for state construction permits (e.g., to the Division of Beaches and Shores in Florida), should also be made aware of specific regulations safeguarding hatchling sea turtles. To be effective, these light restriction ordinances need to be more than just statements of concern.

4. If beach residents are not kept informed about the effects of brightly lit shorelines on hatchlings, it is unlikely that any significant light reduction will occur. Public awareness programs and informed beach owners have fostered a significant decline in hatchling disorientation on Heron Island, Australia and on several islands in the southeast United States (Limpus, et. al., 1981). A teaching package distributed to public schools would be an effective means of informing the public and eliciting their opinions on this issue. Volunteer "lights out" programs should begin prior to the nesting season and could be started by local environmental organizations, condominium owners, and the media. Well-timed newspaper articles, addressing the lighting problem, have been shown to have good results. Hotels and resorts will usually comply with the requests of tourists; therefore, it is important to inform the temporary beach visitors of the lighting issue. This can be accomplished by placing posters and brochures at lights that have been known to disorient turtles, as was done in Australia (Figure 13). A careful and intensive educational campaign is necessary if light restriction ordinances are to be adopted and implemented. With an informed public and proper management practices, artificial lighting can be reduced significantly, thus making the nesting beaches safer for hatchling sea turtles.

APPENDIX A
Study Summaries

SUMMARY I

Behavioral Studies on Turtle Orientation

REFERENCE

TITLE AND SUMMARY COMMENTS

Hooker
(1908)

REPORT ON THE INSTINCTS AND HABITS OF NEWLY-HATCHED LOGGERHEAD
TURTLES

Hatchlings move toward transparent blue and react positively to a downward incline. Intensity may be involved in the hatchlings' reaction toward color. Hatchlings are also positively phototropic and respond to large open areas. Turtles demonstrate no reaction to sound or odor.

Parker
(1922)

THE CRAWLING OF YOUNG LOGGERHEAD TURTLES TOWARD THE SEA

Concluded that there are three ways hatchlings find the sea: (1) positive geotropism (2) away from interrupted horizons and toward open and clear horizons (3) toward blue areas. Studies were in the field during daylight. Orientation is a complex behavior attributed to an unmodified phototaxis.

Noble and Breslau
(1938)

THE SENSES INVOLVED IN THE MIGRATION OF YOUNG FRESH-WATER
TURTLES AFTER HATCHING

The authors worked with three species of freshwater turtles and concluded that orientation was a response to large areas of illumination. These lab findings were supported by observations of diurnal movements of hatchling snapping turtles. Turtles were also attracted to areas of high humidity and demonstrated marked negative geotropism in the dark.

SUMMARY I (cont.)

REFERENCE

TITLE AND SUMMARY COMMENTS

Daniel and Smith
(1947a)

THE MIGRATION OF NEWLY-HATCHED LOGGERHEAD TURTLES TOWARD THE SEA

Photokinetic and phototropic reactions are the principle stimuli involved in the migration of hatchlings toward the sea. Light from the surf is the most intense stimulus and this light is the critical activating and guiding factor for the nest-sea migration.

Daniel and Smith
(1947b)

THE SEA-APPROACH BEHAVIOR OF THE NEONATE LOGGERHEAD TURTLE

Similar conclusions as Daniel and Smith (1974a). Experiments in both the field and lab; the light stimulus is the lone stimulus that produces the kinetic effects which activate and orient the hatchlings toward the ocean. Positive geotropic reactions are weak; color discrimination as a stimulus for orientation was unresolved.

Anderson
(1958)

THE PHOTIC RESPONSES AND WATER-APPROACH BEHAVIOR OF HATCHLING TURTLES

Three freshwater turtle species demonstrated a positive response to light and a negative response to dark masses. Concluded that there are a variety of orientation mechanisms existing in turtles.

Hendrickson
(1958)

THE GREEN TURTLE, CHELONIA MYDAS (LINN). IN MALAYA AND SARAWAK

Light is the main environmental stimulus in the hatchling's orientation from the nest to the sea; green turtle hatchlings do not demonstrate geotaxis on the beach. Most hatchling emergences occurred between midnight and dawn. Hatchlings could be "guided at will" up and down the beach with a flashlight. Young turtles showed a positive tropic response to blue, which may attract individuals to the deep "blue" water; this hypothesis was also reported by Hooker (1911) and Parker (1922).

SUMMARY I (cont.)

REFERENCE	TITLE AND SUMMARY COMMENTS
Sexton (1959)	SPATIAL AND TEMPORAL MOVEMENTS OF A POPULATION OF THE PAINTED TURTLE, <u>CHRYSEMYS PICTA MARGINATA</u> (AGASSIZ) Temperature and water currents are positive orientation mechanisms in the emigration of adult <u>Chrysemys</u>.
Carr and Ogren (1960)	THE ECOLOGY AND MIGRATIONS OF SEA TURTLES, 4. THE GREEN TURTLE IN THE CARIBBEAN SEA The authors conducted a variety of hatchling orientation field tests at various times, beach conditions, weather conditions, etc. Taxes (primarily phototaxis) predominate in the water finding orientation of young sea turtles. Hatchlings orient toward the illumination that comes from the open visible horizon ("openness of outlook"). Although the main goal sense is a visual response to light intensity, a variety of senses are involved in the crawl to the sea. An intense artificial light can override natural attractions and will even draw hatchlings out of the surf. Turtles held in captivity for long periods of time can retain the sea-orientation sense.
Caldwell and Caldwell (1962)	FACTORS IN THE ABILITY OF THE NORTHEASTERN PACIFIC GREEN TURTLE TO ORIENT TOWARD THE SEA FROM THE LAND, A POSSIBLE COORDINATE IN LONG-RANGE NAVIGATION Research was conducted on juvenile and subadult green turtles. The stimuli eliciting the sea approach behavior was photic; no evidence was found for a negative response to dark objects.

SUMMARY I (cont.)

REFERENCE	TITLE AND SUMMARY CONTENTS
McFarlane (1963)	DISORIENTATION OF LOGGERHEAD HATCHLINGS BY ARTIFICIAL ROAD LIGHTING Artificial lights on the southeast Florida coast provide enough stimulus to overcome natural taxes in the hatchlings sea-finding attempts. Hatchlings were found disoriented and killed on highways that parallel the beaches as they were attracted to mercury vapor streetlights.
Ortleb and Sexton (1964)	ORIENTATION OF THE PAINTED TURTLE, <u>CHRYSEMYS PICTA</u> Adult <u>Chrysemys</u> were able to discriminate between various light intensities under laboratory conditions. Light and water temperature were two factors important in orienting adult painted turtles.
Carr (1965)	THE NAVIGATION OF THE GREEN TURTLE The hatchling orientation mechanism is a response to some quality of light over the open water. The light-seeking urge that guides them from the nest to the sea is effective even when the water is hidden by dunes or other structures under natural conditions.
Mrosovsky and Boycott (1966)	INTRA- AND INTERSPECIFIC DIFFERENCES IN PHOTOTACTIC BEHAVIOR OF FRESH-WATER TURTLES Laboratory experiments on the freshwater turtle, <u>Pseudemys scripta elegans</u>, showed some individuals were negatively phototactic while others were positively phototactic. Differences were not related to sex, weight, lab conditions, or levels of illumination.

SUMMARY I (cont.)

REFERENCE

TITLE AND SUMMARY COMMENTS

Ehrenfeld and Carr
(1967)

THE ROLE OF VISION IN THE SEA-FINDING ORIENTATION OF THE GREEN
TURTLE (CHELONIA MYDAS)

The sea-finding orientation of the green turtle is mainly a visual process. Filter experiments indicate: (1) that sea turtles are less sensitive to red light, but that color is an unlikely mechanism for sea-finding; (2) blurred images do not impair orientation; (3) polarized reflected light is not the main orienting stimulus when the water is not in view; (4) the beach horizon and landscape horizon are the important visual orientation cues. The authors point out the need for further research to determine what specific mechanisms are involved (i.e. avoidance of dark landward features, attraction of lighter open areas, or a combination of the two). Hatchlings orient successfully even when the sun, moon, and stars are obscured.

Mrosovsky and Carr
(1967)

PREFERENCE FOR LIGHT OF SHORT WAVELENGTHS IN HATCHLING GREEN SEA
TURTLES, CHELONIA MYDAS, TESTED ON THEIR NATURAL NESTING BEACHES

Hatchlings show a positive reaction to light with a preference for the shorter wavelengths of blue and green as compared to red. These shorter wavelengths are more effective than red in distracting hatchlings away from the sea. Hatchlings also orient toward lights with the greatest intensity. There is a peak response for brightness and short wavelengths under conditions of darkness (scotopic conditions).

Mrosovsky
(1968)

NOCTURNAL EMERGENCE OF HATCHLING SEA TURTLES: CONTROL BY THERMAL
INHIBITION OF ACTIVITY

Demonstrated that a thermal inhibition of activity is the major factor in limiting the hatchlings to a nocturnal emergence; activity inhibited at 28.5°C. The paper discusses the advantages of a night emergence once the beach sand cools (e.g. escape predators in darkness, high temperatures lethal to hatchlings).

SUMMARY I (cont.)

REFERENCE	TITLE AND SUMMARY COMMENTS
Ehrenfeld (1968)	THE ROLE OF VISION IN THE SEA-FINDING ORIENTATION OF THE GREEN TURTLE (<u>CHELONIA MYDAS</u>). 2. ORIENTATION MECHANISM AND RANGE OF SPECTRAL SENSITIVITY Color filter experiments on adult green turtles confirm that the sea-finding stimulus is primarily based on light intensity discrimination (phototropotactic) rather than color discrimination. Turtles with one eye blindfolded (unilateral) exhibited continuous turns toward the side of the uncovered eye. Sea turtles have a blue-green sensitivity which may be an adaptation to the transmission properties of saltwater. The adult green turtle has an approximate spectral sensitivity of 350 nm to 650 nm.
Mrosovsky and Shettleworth (1968)	WAVELENGTH PREFERENCES AND BRIGHTNESS CUES IN THE WATER-FINDING BEHAVIOR OF SEA TURTLES Hatchlings demonstrate a blue stimulus preference over red, but this depends on brightness (red with a higher intensity can be preferable over a dim blue). Hatchlings balance the brightness inputs in both eyes enabling them to maintain an orientation toward the illumination from an open horizon (in most natural conditions this is seaward). Weather conditions can affect orientation. High temperatures (above 24°C) can weaken the reaction to photic stimuli.
Koch et. al. (1969)	THE PROBLEM OF OPEN-SEA NAVIGATION: THE MIGRATION OF THE GREEN TURTLE TO ASCENSION ISLAND Discusses the theories of the adult green turtle's island-finding feat; emphasis is on the possibility that chemoperception may be the long range navigation mechanism used by green turtles at sea.

SUMMARY I (cont.)

REFERENCE	TITLE AND SUMMARY COMMENTS
Mrosovsky (1970)	THE INFLUENCE OF THE SUN'S POSITION AND ELEVATED CUES ON THE ORIENTATION OF HATCHLING SEA TURTLES Any type of visual stimulus will have some effect on the hatchling's sea-finding orientation. Orientation is a relatively simple tropotactic reaction to light. The sun can influence the direction taken by hatchling green and hawksbill turtles on their way to the sea. Artificial lights introduced into a uniform visual horizon can orient hatchlings toward the illumination.
Limpus (1971)	SEA TURTLE OCEAN-FINDING BEHAVIOR Hatchlings orient toward a combination of cues, primarily the topography of the horizon and light intensity. Author suggests that the topography of the surrounding horizon line is a more important cue than the brightness differential that exists between the seaward and landward direction.
Mrosovsky (1972)	THE WATER-FINDING ABILITY OF SEA TURTLES Hatchlings react tropotactically to light (i.e. they compare light intensities simultaneously in both eyes and orient according to the balance struck). This paper contains a good review of earlier behavioral studies conducted on hatchling orientation. In "arena obstruction experiments" turtles headed for the center of the open horizon, thereby basing their orientation on a balance of light intensities from a wide field of view. The brightness differences between seaward and landward directions occur mainly at the respective horizons, but lights high above the horizon will have some effect on orientation. The author proposes several physiological central mechanisms for the sea-finding behavior in hopes of initiating further research.

SUMMARY I (cont.)

REFERENCE

TITLE AND SUMMARY COMMENTS

Verheijen and Wildschut
(1973)

THE PHOTIC ORIENTATION OF HATCHLING SEA TURTLES DURING WATER-FINDING BEHAVIOR

Hatchlings move in the direction of the brightest light intensity and not in the direction opposite the darkest distribution, although under natural beach conditions these two light distributions are opposites of each other. It is unlikely that hatchlings can discriminate color at night under low illumination. Hatchlings determine the brightest direction by balancing the light stimuli entering the eye thru an "input cone" containing a large field of acceptance.

Mrosovsky and Shettleworth
(1974)

FURTHER STUDIES OF THE SEA-FINDING MECHANISM IN GREEN TURTLE HATCHLINGS

The authors examined the details of the mechanisms determining the tropotactic reaction to light. Visual inputs in the nasal region of the eye are associated with turning toward the midline (contralateral) and inputs in the temporal field are associated with turning away from the midline (ipsilateral). Light from different directions contribute in differing ways in the sea-finding orientation of hatchlings.

Mrosovsky and Shettleworth
(1975)

ON THE ORIENTATION CIRCLE OF THE LEATHERBACK TURTLE, DERMOCHELYS CORIACEA

Orientation circling occurs in both adult and hatchling leatherbacks under natural beach conditions. Artificial light has a pronounced effect on leatherback orientation. Sea-finding between hatchling green turtles and leatherbacks differ in (1) leatherbacks have orientation circling; (2) leatherbacks were slower and less direct; (3) when unilaterally blindfolded, half of the leatherbacks moved toward the covered eye whereas most greens moved toward the open eye. No conclusive evidence of why leatherbacks have orientation circles.

SUMMARY I (cont.)

REFERENCE	TITLE AND SUMMARY COMMENTS
Burger (1976)	BEHAVIOR OF HATCHLING DIAMONDBACK TERRAPINS (<u>MALACLEMYS TERRAPIN</u>) IN THE FIELD Hatchlings usually emerge during the day and orient toward the closest vegetation; freshwater turtles have better land vision than marine turtles and may play a more important role in orientation.
Philibosian (1976)	DISORIENTATION OF HAWKSBILL TURTLE HATCHLINGS, <u>ERETMOCHELYS IMBRICATA</u> , BY STADIUM LIGHTS This paper documents the disorientation of hawksbill hatchlings in the U.S. Virgin Islands by artificial landward lights. The author expresses the need for light reduction and protection of nesting habitats.
Mann (1977)	IMPACT OF DEVELOPED COASTLINE ON NESTING AND HATCHLING SEA TURTLES IN SOUTHEASTERN FLORIDA Hatchlings were disoriented by artificial lights when the light sources were directed visible from the nest site. Beach barriers, such as sea walls, often prevented disoriented hatchlings from leaving the beach landward; mortality of disoriented hatchlings varied (0-96%) depending on barriers. Hatchlings often oriented correctly on nights of a bright moon even in areas where disorientation usually occurs. Concluded that light intensity cues low on the horizon are of primary importance; more research needed on whether hatchlings are disoriented by coastal lights after entering the sea.

SUMMARY I (cont.)

REFERENCE	TITLE AND SUMMARY CONTENTS
Mrosovsky (1978a)	EFFECTS OF FLASHING LIGHTS ON SEA-FINDING BEHAVIOR OF GREEN TURTLES Hatchlings are positively phototropotactic (i.e. they react toward light and toward an open horizon, they balance the brightness cues between the open horizon and the darker landward mass). The intermittency of flashing light is not as important in disorientation as the amount of light (intensity) being received by the hatchling. Hatchlings integrate light over a wide time span rather than reacting to brief flashes of light.
Van Rhijn (1979)	OPTIC ORIENTATION IN HATCHLINGS OF THE SEA TURTLE, <u>CHELONIA MYDAS</u>, 1. BRIGHTNESS: NOT THE ONLY OPTIC CUE IN SEA-FINDING ORIENTATION Turtles that were blindfolded for over 24 hours oriented down the slope of the beach and not always in the brightest direction (i.e. not orienting strictly tropotactically). A multiple input system is probably involved.

SUMMARY II

Anatomical and Physiological Studies on Turtle Vision

REFERENCE	TITLE AND SUMMARY COMMENTS
Walls (1942)	THE VERTEBRATE EYE AND ITS ADAPTIVE RADIATION Marine turtles lack some of the efficient mechanisms of accommodation found in freshwater turtles and are myopic on land. Color vision is present in most reptiles.
Quaranta (1952)	AN EXPERIMENTAL STUDY OF THE COLOR VISION OF THE GIANT TORTOISE Tortoises can discriminate brightness and color (blue, green, red). This paper discusses the importance of controlling the brightness factor when trying to discriminate colors (i.e. it may be the brightness factor and not hues that the turtle is responding to).
Armington (1954)	SPECTRAL SENSITIVITY OF THE TURTLE, <u>PSEUDEMYD</u> This paper discusses two visual behaviors of <u>Pseudemys</u> : (1) its spectral sensitivity and (2) the possibility of a functional night-vision mechanism. The results are in agreement with the hypothesis that turtles possess both photopic (daylight vision) and scotopic (night vision) retinal mechanisms.
Forbes et. al. (1958)	ELECTRORETINOGRAM OF FRESH-WATER TURTLE: QUANTITATIVE RESPONSES TO COLOR SHIFT Laboratory experiments on <u>Pseudemys scripta</u> ; results suggest that the turtle retina has three types of receptors in the cone system. The peak sensitivities are in the red, orange, and yellow-green; there are a few rods with peak sensitivities in the blue-green.

SUMMARY II (cont.)

REFERENCE

TITLE AND SUMMARY COMMENTS

Fraenkel and Gunn
(1961)

THE ORIENTATION OF ANIMALS

This reference primarily discuss kineses, taxes and compass reactions in invertebrate orientation.

Granda
(1962)

ELECTRICAL RESPONSES OF THE LIGHT AND DARK ADAPTED TURTLE EYE

The author experimented on the yellow-bellied turtle (Pseudemys scripta). The eye of Pseudemys is cone dominated and what previous investigators were describing as rods were actually intermediate cell structures whose function is not known. The paper tries to assess whether the turtle retina has both photopic and scotopic functions.

Granda and Stirling
(1966)

THE SPECTRAL SENSITIVITY OF THE TURTLE'S EYE TO VERY DIM LIGHTS

The authors worked on the freshwater turtle Pseudemys scripta elegans. The spectral sensitivity studies demonstrated wide differences between the individual subjects, but in general there was a broad sensitivity toward the shorter wavelengths (blue-green).

Ehrenfeld and Koch
(1967)

VISUAL ACCOMMODATION IN THE GREEN TURTLE

The green turtle is extremely myopic (near-sighted) when the eyes are out of the water, whereas freshwater turtles accommodate over a wider range in both air and water. Retinoscopic and anatomical evidence indicate that the orientation of sea turtles is not dependent on sharp retinal images; therefore, celestial navigation seems unrealistic for open-sea migrations.

SUMMARY II (cont.)

REFERENCE	TITLE AND SUMMARY COMMENTS
Granda and Haden (1970)	RETINAL OIL GLOBULE COUNTS AND DISTRIBUTIONS IN TWO SPECIES OF TURTLES: <u>PSEUDEMYS SCRIPTA ELEGANS</u> (WIED) AND <u>CHELONIA MYDAS</u> (LINNAEUS) Globules are usually associated with cone structures. In <u>C. mydas</u> and <u>P. scripta</u> cones predominate and rods are few. The distribution of globules in <u>Chelonia mydas</u> are not organized in a discernable pattern, therefore differential glare and acuity in the binocular field have minimal roles when compared to freshwater turtles.
Granda, A.M. (1979)	TURTLES: PERSPECTIVES AND RESEARCH Chapter 13, entitled "Eyes and Their Sensitivity to Light of Differing Wavelengths", contains a current review of turtle eye morphology and its spectral sensitivity.

APPENDIX B

Tables

TABLE 3

Types of light sources causing sea turtle hatchling disorientation with recommendations for solutions.

LIGHT SOURCE	PROBLEM INDEX*	OCCURRENCE IN SOUTHEAST U.S.	POTENTIAL SOLUTIONS**
Beachfront Building Lights			
A-Floodlights	1	common	(1) (2) (3) (4) (5) (6) (7)
B-Wall Mount Fixtures	2	common	(1) (2) (5) (6) (7)
C-Landscape/Walkway Lights	2	common	(1) (2) (3) (4) (5) (6) (7)
Streetlights and Related Public Light Fixtures	1	common	(1) (2) (3) (6)
Vehicular	2	moderate	(1)
Flashlights	3	common	(1) (5)
Construction Lights	2	occasional	(1) (2) (4) (5)
Offshore Lights	unknown	occasional	(2) (4)

* Problem Index: Based on the intensity of the light source; 1=high, 2=moderate, 3=low.

** Potential Solutions:

- (1) Eliminating the Light Source
- (2) Shading or Screening the Light Source
- (3) Adapting Timers to the Light Source
- (4) Lowering the Elevation of the Light Source
- (5) Reducing the Intensity of the Light Source
- (6) Replacing the Existing Light Source with a Modern Alternative Source
- (7) Using Structural or Natural Barriers to Block the Light Source

Table 1

Summary of six beaches in southeast Florida with reference to artificial beachfront lights and marine turtle hatchling disorientation (from Mann 1977, Thesis, Florida Atlantic University).

Beach	Beach Length (miles)	Artificial Lighting	No. of Nests Used in Sample	Overall Mean Directional Heading Taken by Emergent Hatchlings
North Boca Raton A	1.5	Natural dune, without light	9	East
North Boca Raton B	1.42	Bright streetlights	15	Variable, East and West
Highland Beach	2.76	Very little lighting in residential, basically dark	68	East
Fort Lauderdale	0.9	Widespread, streetlights visible from any point on beach	14	West
Lauderdale-By- The-Sea	1.82	Widespread, intensities variable; main source is outdoor building lights	148	Highly variable East and West
Pompano Beach	1.48	Widespread; streelights and building lights prominent	84	Variable, East and West
Hillsboro Beach	0.93	Not intense in most areas, with some sections quite dark	58	East

Table 2

PURCHASE AND OPERATING COST COMPARISON FOR INCANDESCENT AND HIGH INTENSITY DISCHARGE (HID) LIGHTING GUIDE

	500 W Incan- descent	400 W Mercury Vapor	400 W Metal Halide	400 W Sodium Lamp
No. of Fixtures Needed to Light a Typical Industrial Area	21	9	6	4
Approx. Fixture and Bulb Cost	\$ 600	\$1,050	\$890	\$820
Energy at 6.5¢ Per KWH *	\$2,620	\$ 990	\$660	\$440
Bulb & Fixture Maintenance Cost	\$ 200	\$ 40	\$ 90	\$ 50
Total Yearly Operating Cost	\$2,820	\$1,030	\$750	\$490

(*) Based on 80 hours of operation per week.

(From: Grainger's Wholesale Net Price Catalog, no. 365. W. W. Grainger, Inc.)

APPENDIX C

Figures

FIGURE 1

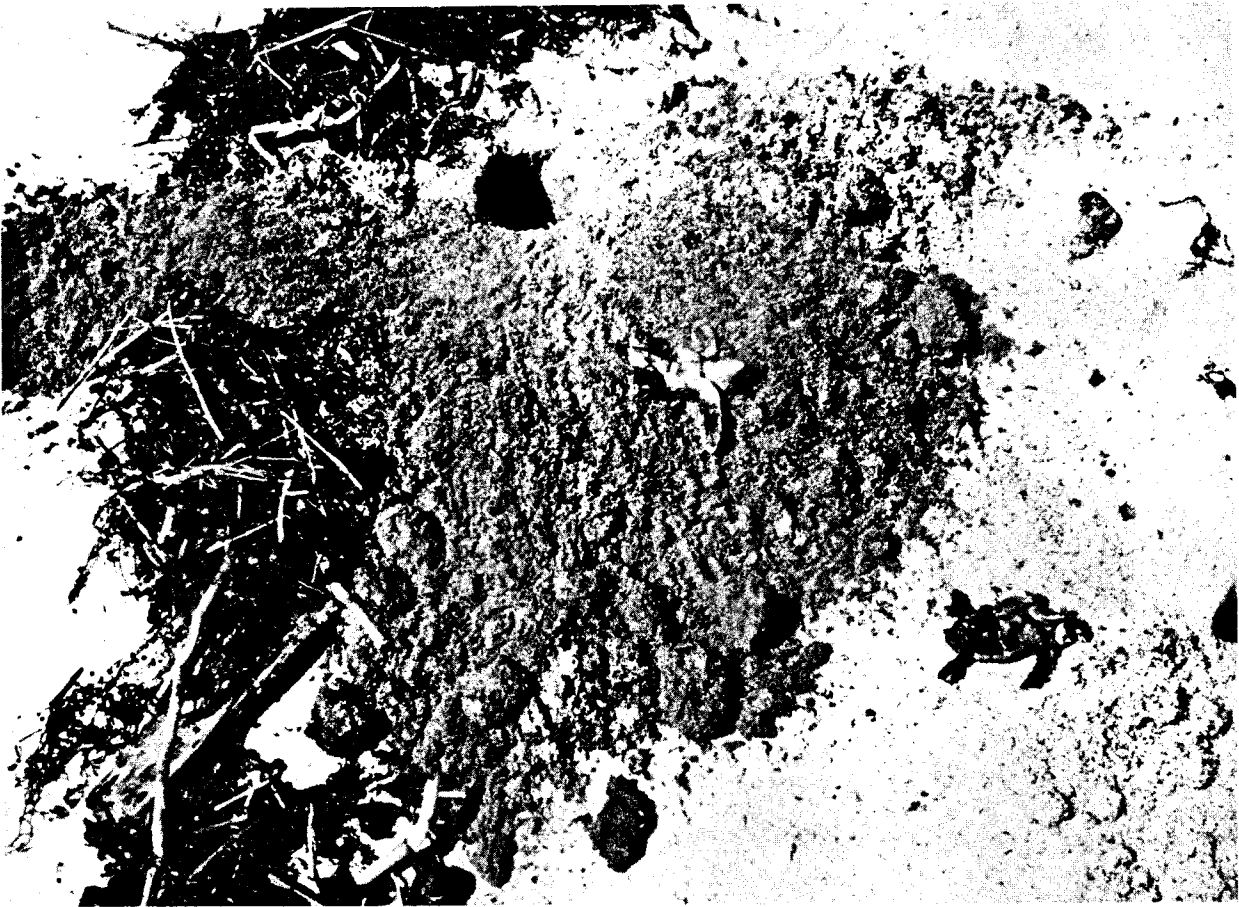


Figure 1

Several dead loggerhead hatchlings (Caretta caretta) killed by ghost crabs (Ocypode sp.). Hatchlings that are disoriented by artifical lights are more vulnerable to predators.

FIGURE 2



Figure 2

Beachfront floodlight with no apparent purpose.

FIGURE 3



Figure 3

High intensity floodlights are particularly detrimental to hatchlings for they are usually located on roofs of condominiums and illuminate large sections of beach.

FIGURE 4



Figure 4

While individual light intensities for wall mount light fixtures are usually low, they are often quite numerous and can significantly brighten the landward horizon.

FIGURE 5

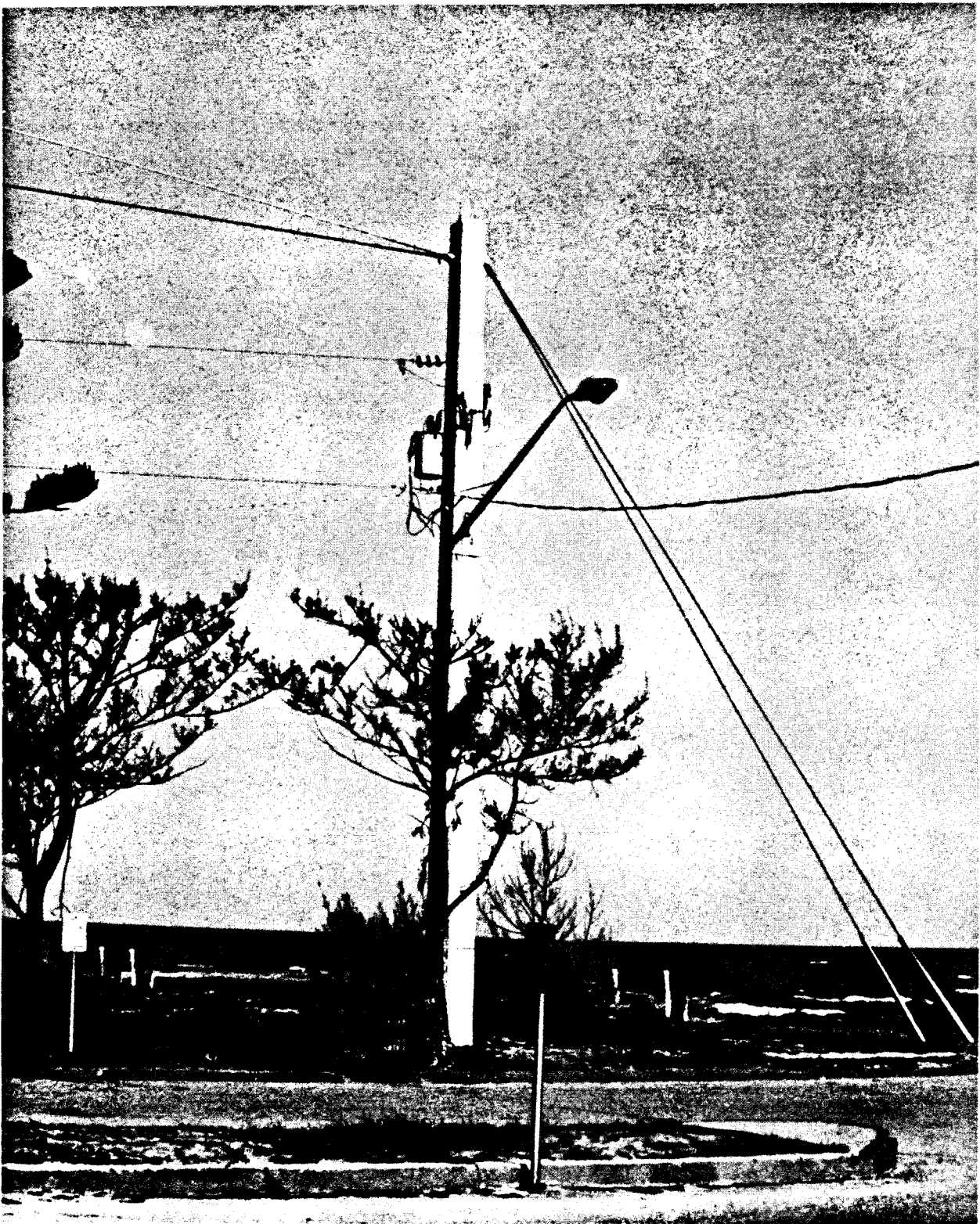


Figure 5

A high intensity streetlight that is directly visible from the beach. Such light sources are a primary cause of hatchling disorientation.

FIGURE 6

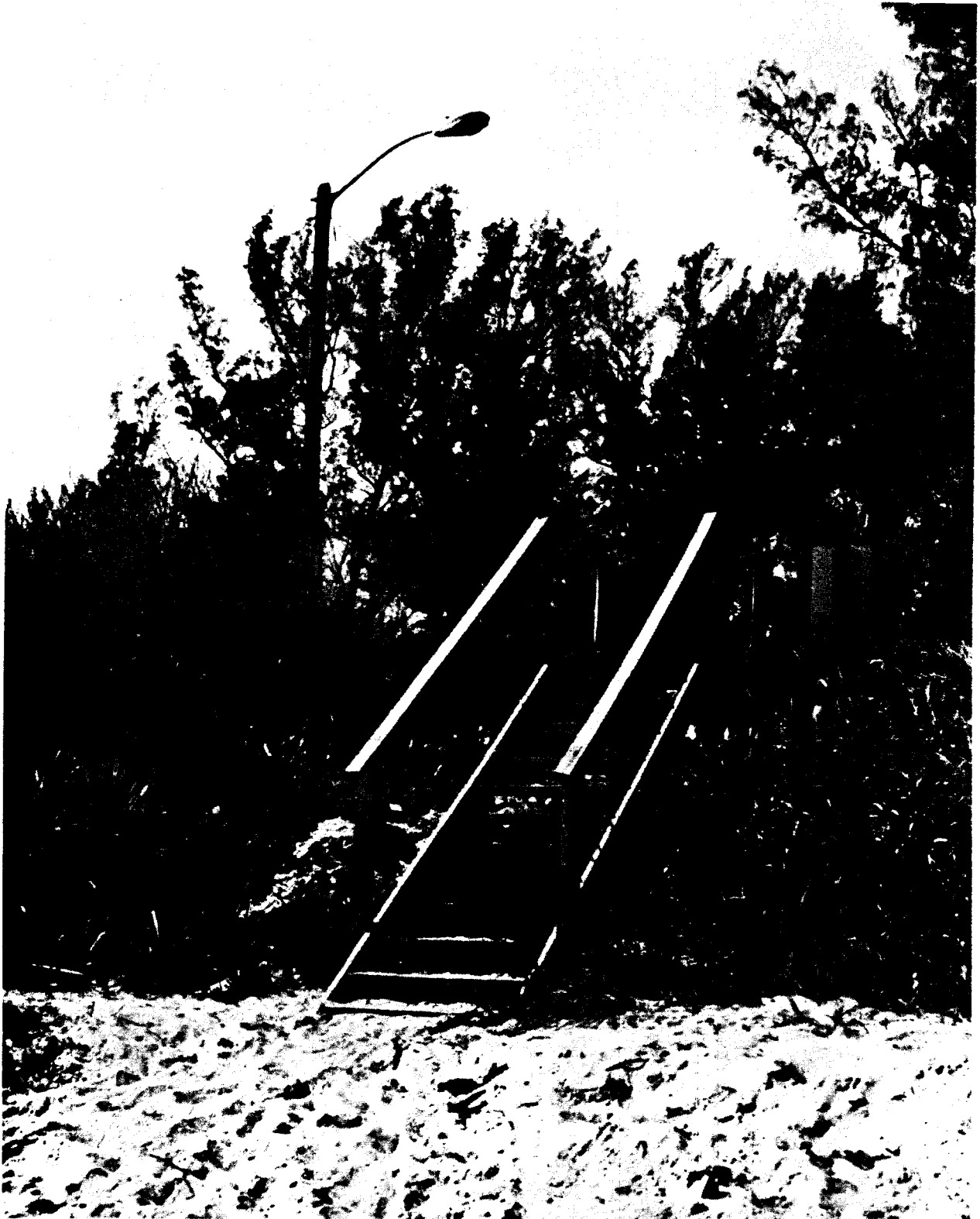


Figure 6

A high intensity streetlight located on the primary dune to illuminate a public access area. A single light like this can disorient hundreds of hatchlings in a nesting season.

FIGURE 7A and 7B

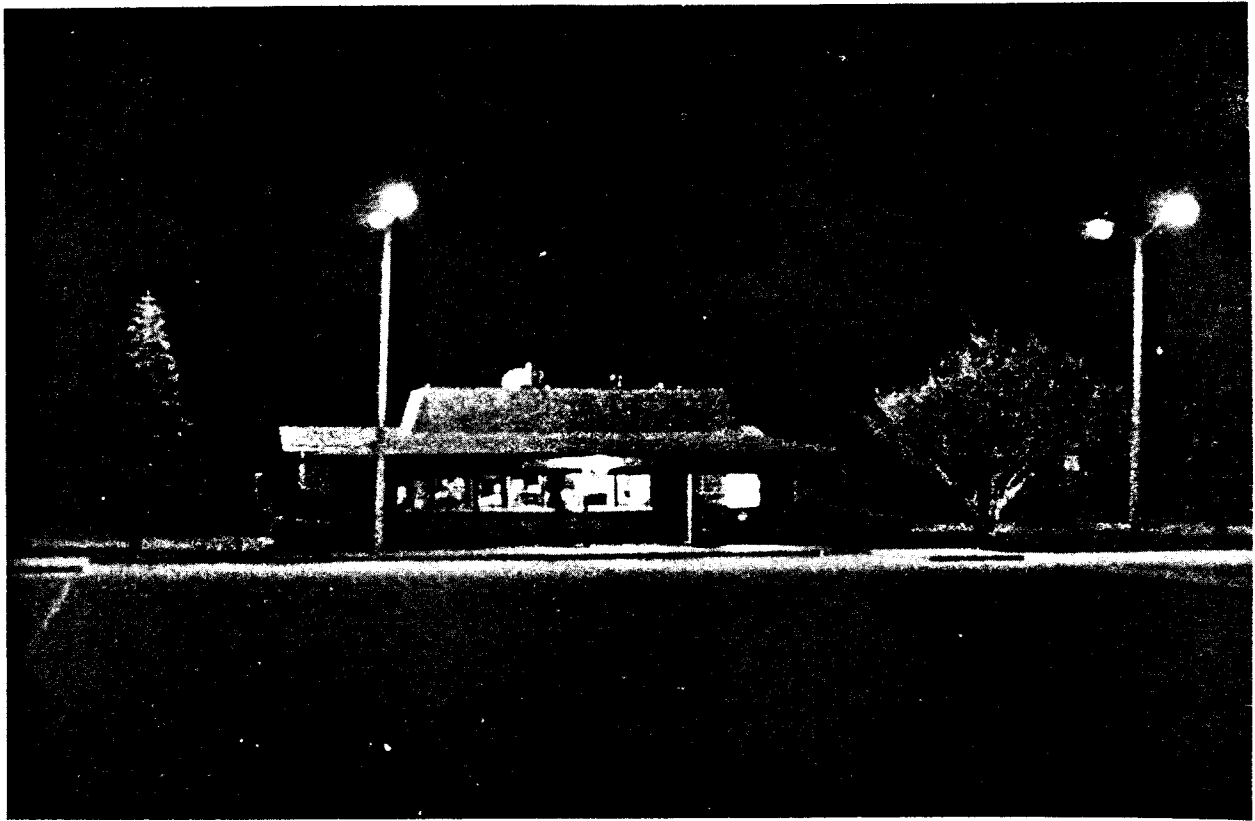


Figure 7A and 7B

Bright multiple lights that are used to illuminate beach boardwalks, public parks, parking lots, and resort areas attract hatchlings over the dune and into areas where many are killed by vehicular traffic.

FIGURE 8



Figure 8

High intensity streetlights can be fitted with metal shields to prevent direct light from being cast on the beach.

FIGURE 9



Figure 9

Wall mount light fixtures can be fitted with hoods to eliminate excess illumination.

FIGURE 10

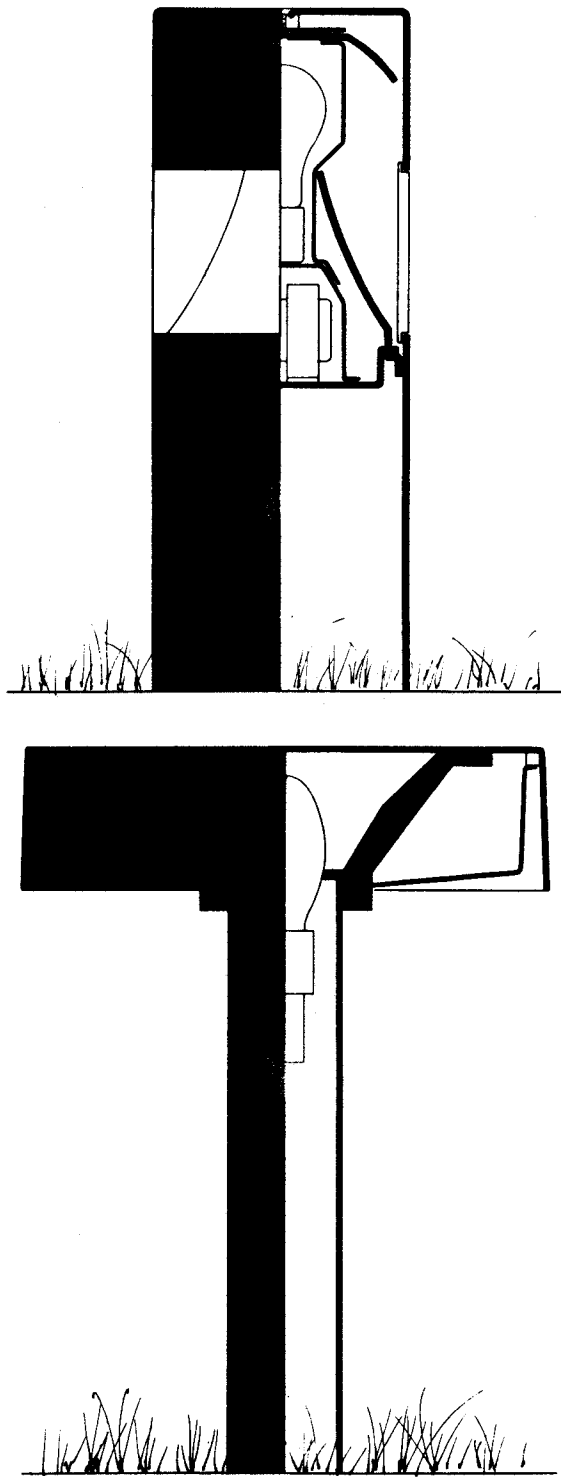


Figure 10

Low-profile luminaires suitable for illuminating beach walkways and landscape areas. Multiple reflectors redirect light downward from a hooded lamp source. (Illustrations from Lightolier, Coltsneck, New Jersey)

FIGURE 11

OPTICAL SYSTEM

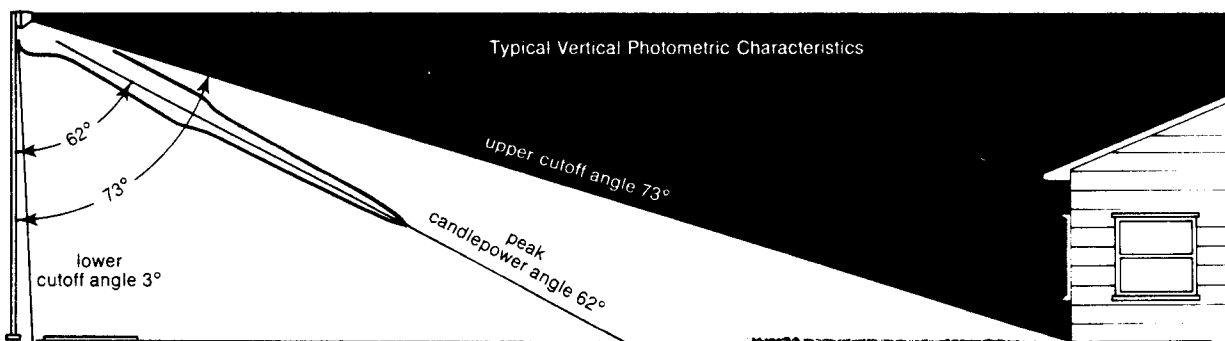
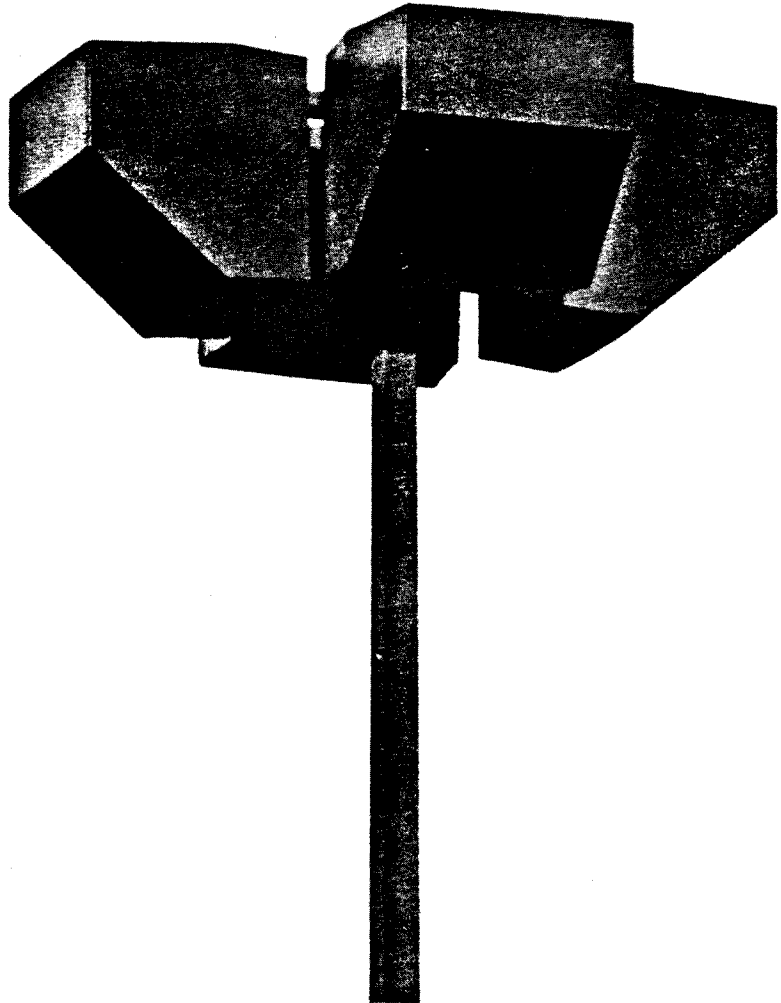
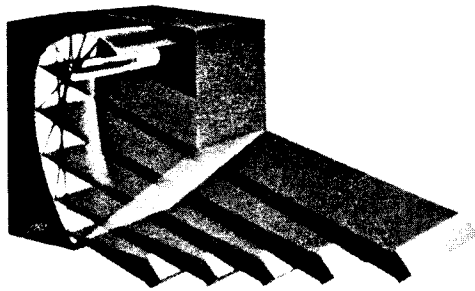


Figure 11

A modern alternative high intensity light source. The reflector system allows for precise upper and lower cutoff angles. Such lights can be used for highways and parking lots. (Illustrations are of the Crouse-Hinds CLX Precise Light, from the Crouse-Hinds Company, Syracuse, New York)

FIGURE 12

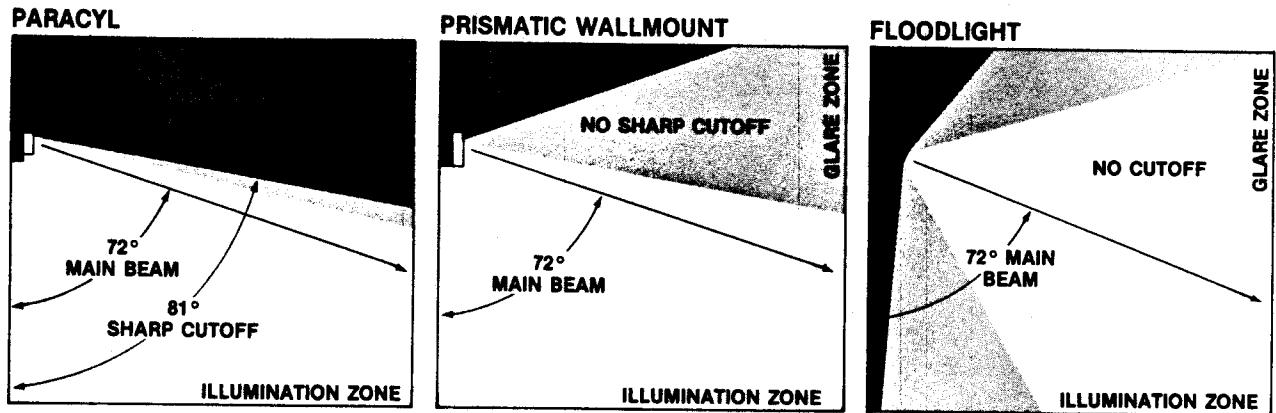


Figure 12

A comparison of a modern Paracyl luminaire, a prismatic wall mount fixture, and a floodlight showing the various cutoff angles. The floodlight and the prismatic would be unacceptable in beachfront areas because they allow light to escape at high angles that could be cast over the dune. (Illustrations from Moldcast Lighting, A Division of Wylain, Inc.)

FIGURE 13

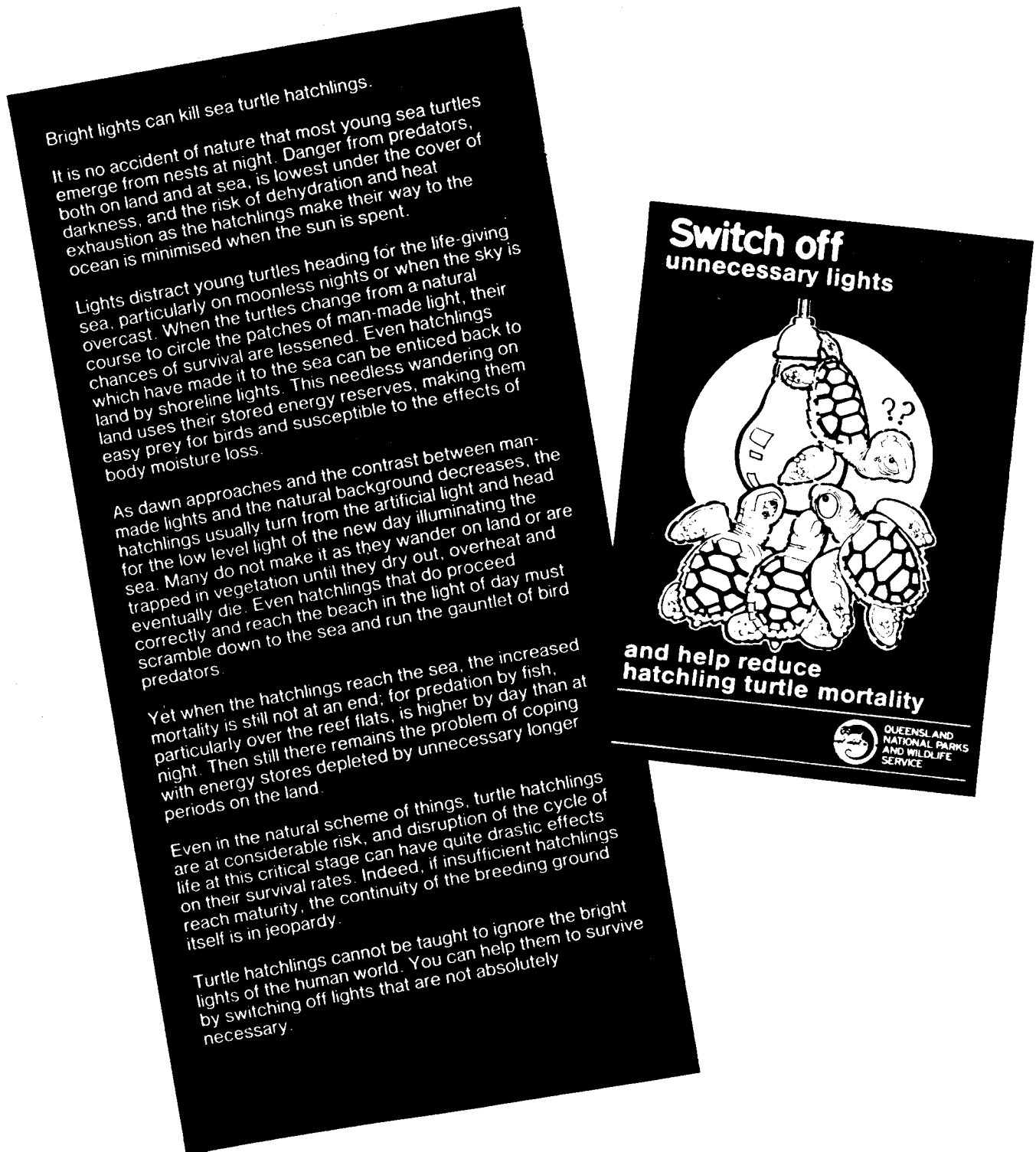


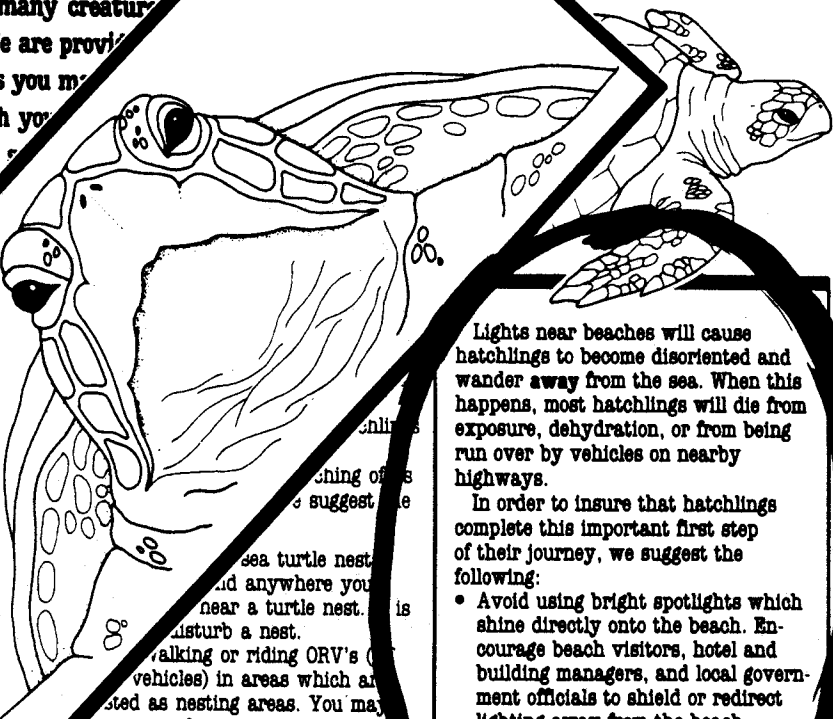
Figure 13

A brochure and sticker used in a public awareness campaign by the Queensland National Park and Wildlife Service in Australia. Public awareness programs can help foster a significant decline in hatchling disorientation.

FIGURE 14



Whether you are a resident or a visitor to the beach environment with many creatures and endangered sea turtles. We are providing information so that any encounters you may have will be more enjoyable for both you and the turtles. These suggestions may cause a change in behavior, but they may also make an important contribution to the survival of these ancient creatures.



Lights near beaches will cause hatchlings to become disoriented and wander away from the sea. When this happens, most hatchlings will die from exposure, dehydration, or from being run over by vehicles on nearby highways.

In order to insure that hatchlings complete this important first step of their journey, we suggest the following:

- Avoid using bright spotlights which shine directly onto the beach. Encourage beach visitors, hotel and building managers, and local government officials to shield or redirect lighting away from the beach. Security lighting can be screened with vegetation to reduce glare on the beach.
- Avoid driving vehicles up in the dune area where tires will form deep ruts. Hatchlings can become trapped and crawl along in such ruts instead of crawling to the sea.
- Allow hatchlings to make their way to the sea, if you should encounter them on the beach. Keeping hatchlings is illegal.
- Report hatchlings which have wandered away from the ocean to the proper authorities. Your assistance may be requested in aiding these hatchlings.

Nesting Turtles

The loggerhead sea turtle comes ashore to nest from Florida to Carolina. The leatherback comes to the coast of Florida. The green sea turtle comes to the coast of Florida and the Hawaiian Islands.

Attention Beach Users

The following are suggestions for beach users to help protect sea turtles and their nests:

- Avoid walking or driving on the beach near a turtle nest.
- Do not disturb a nest.
- Do not walk or ride ORV's (off-road vehicles) in areas which are marked as nesting areas. You may step on or drive over a nest and crush the eggs.
- Put litter in trash cans or take it home for disposal. Heavy equipment is used to clean up litter on the beach; this crushes the eggs and hatchlings.
- Cooperate with researchers and managers by not disturbing markers or protective screening over nests. Such nests are being studied and protected.
- Contact the proper authorities if you see anyone disturbing a nest.

The Nests

Sea turtle eggs must remain undisturbed in the warm sand for about 60 days before they hatch. When the eggs hatch, the hatchlings remain in the nest for several days to absorb their energy.

The Hatchlings

Hatchlings dig their way out of a nest in a united effort and usually emerge at night. They then make their way down the beach and enter the surf. Some researchers believe that their crawl to the sea is important to find their proper course in swimming out to sea. Other researchers believe that the hatchlings orient into the waves only when they reach the sea. Nonetheless, the race of the hatchlings from their nest to the sea is crucial.

Turtle Carcasses

Many kinds of accidents befall sea turtles when they enter Gulf of Mexico and Atlantic coastal waters. Some are caught on fishing lines. Others are hit by boat propellers. Still others are caught and die in commercial fishing nets, and others die of natural causes. Information gained from the study of such dead turtles may be important in

Figure 14

A brochure produced by the Sea Turtle Rescue Fund of the Center for Environmental Education.

Figure 15

Sea turtle protection measures from the "Hutchinson Island Resource Planning and Management Plan." Adopted October 6, 1983.

e. Sea Turtle Protection

1. Mechanical beach cleaning, to the greatest extent possible, should be restricted from May to October (turtle nesting season). For cleaning activities during this time period, beach cleaners will be required to use more labor intensive practices designed to reduce impacts to turtle nesting habitat. Required practices may include hand cleaning, use of lighter equipment with low pressure, low profile tires and rakes which penetrate the beach no more than 2 inches. Access to the beach may be restricted to designated areas and cleaning activities may be restricted to the strand line. Beach cleaners shall be required to obtain a CCCL permit for operations beyond the control line and have their method of operations and equipment approved by the Florida Department of Natural Resources as a part of the special conditions of the CCCL permit.
2. Site and building plans for construction of single or multi-family dwellings, parking lots, dune walkovers or any other lighted structure within the direct line of sight of the beach shall incorporate the following:
 - Low profile and low intensity lighting will be used in parking lots and such lighting shall be positioned so that the source of light is not visible from the beach.
 - All lights on balconies will be shielded from the beach.
 - Floodlights on buildings on or adjacent to the beach shall be positioned so that the source of light is not visible from the beach or if required for safety, positioned in such a manner as to minimize impacts on turtles.
 - Where lights are used, low profile and low intensity shielded lights will be used on dune walkovers.
 - Tinted glass should be used on oceanside living areas of high rise structures within line of sight of the beach.

South beach tops for nesting turtles

By MIKE THOMAS
TODAY Staff Writer

Helter-skelter tracks were dispersed along a small stretch of beach, looking like they came from a small bicycle driven by an uncoordinated child.

They led to a group of baby sea turtles lying in front of a brightly lighted condominium, most of them dead. They had run themselves into exhaustion and died. The survivors were being eyed by hungry ghost crabs.

The small reptiles couldn't hear the surf, where two months earlier a massive loggerhead turtle emerged to lay her eggs. Nature instructs them to follow the light after emerging from their nest, and the moon's reflection on the ocean couldn't compete with the bright condominium lights.

"We're all realizing a little too late how important South Brevard is to the South Atlantic sea turtles," University of Central Florida biologist Lew Ehrhart said. "It is the best nesting beach in the United States. How long it will stay that way I don't know."

Research by Ehrhart and a handful of graduate students is showing the South Brevard beach probably is the largest turtle nursery in the United States, averaging a nest every 9 feet this year with almost two months to go in the nesting season. About five to 10 times the number of turtles nest there as on the undeveloped Playalinda Beach, another large nursery Ehrhart studied for seven years under a

NASA grant.

Since mid-May, Ehrhart has documented about 5,000 nestings on the south beaches, primarily from loggerhead turtles. Only 14 nests have been laid by the more endangered green turtle.

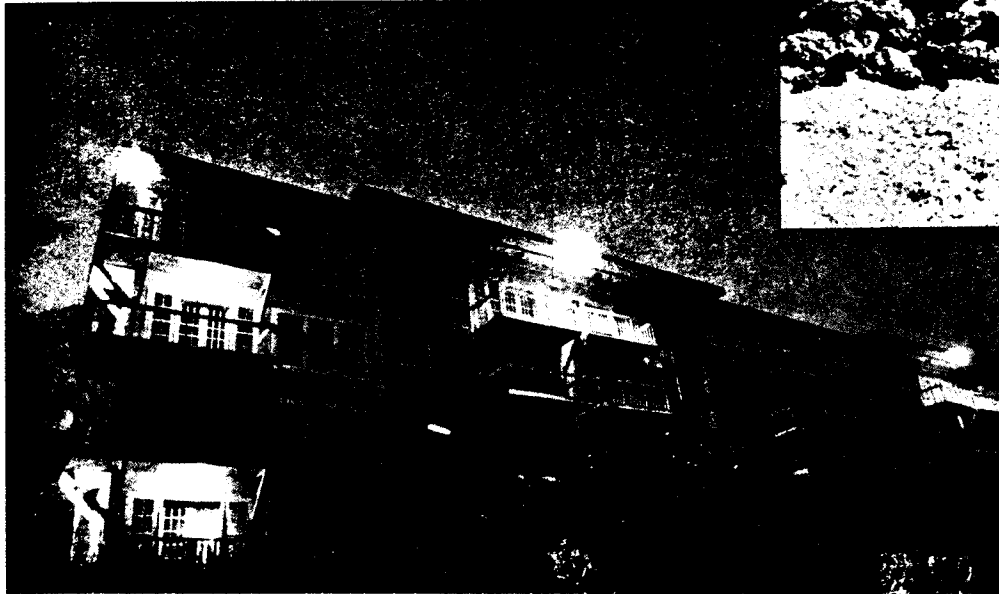
Ehrhart said he can't pinpoint why the south beach is so popular. Perhaps it is because of the heavy wave action that pulverizes the sand into a fine mixture easy for nesting turtles to dig into, he said. The steeper slope of the beach also may attract the reptiles, which come to Brevard from as far away as the Bahamas to lay eggs.

Ehrhart is conducting his research from a dingy south beach apartment, the cheapest he could find. Armed with only a \$10,000 grant from the World Wildlife Fund, three dilapidated motor scooters, a worn net, a sputtering boat and student volunteers, Ehrhart is diagnosing the most serious threat facing the endangered reptiles: beachfront lights.

The problem gets little publicity. The tiny, dehydrated turtle corpses generate little public outrage because the public never sees them. The crabs see to that.

Ehrhart's research tools pale in comparison to federal turtle projects, where hundreds of thousands of dollars are spent on monitoring and protecting turtle populations in Port Canaveral, the densest congregation of adult loggerhead turtles in

See TURTLES, 3B



After emerging from their nests, baby sea turtles are supposed to head for the ocean. But bright lights from beachside condominiums, such as this one in South Brevard, confuse the hatchlings, whose instinct is to follow the lights.

TODAY Color Photo
by Malcolm Drenmark

Figure 16

Newspaper articles that contributed to reductions in beachfront lighting in south Brevard County, Florida, during the 1982 sea turtle nesting season. (From the Today newspaper)

Turtles favor south beach

TURTLES, From 1B

the country.

Mutilated by dredge ships deepening the port channel or shrimpers who inadvertently catch them in dragnets, beached turtle carcasses present a gruesome picture along the Central Brevard coastline. The highly visible problem has prompted federal officials to act quickly, responding to the deaths with radio transmitters, airplane surveys, dredging studies and a turtle trawler.

Federal officials admit they are throwing their money at a secondary problem. The major threat to turtles is on the beaches, where thousands of hatchlings never even reach the ocean.

But the federal Endangered Species Act, in most cases, doesn't allow agencies to act on the lighting problem, said Charles Fuss, director of enforcement for the National Marine Fisheries office in St. Petersburg.

The agency only can protect endangered species from federal projects or projects requiring federal permits, which excludes most condominium projects.

So Ehrhart is left with what little funds he can generate from private conservation organizations to study the problem and try to solve it, primarily through public education.

"There are a lot of people in South Brevard who care about turtles," Ehrhart said. "That's about the only chance they have."

But Ehrhart may get some help from Brevard County Commission Chairman Joe Wickham, who said the county may consider a beach light restriction rule for the crucial months of July to October.

Managers of some brightly lighted condominiums and motels contacted by TODAY Friday agreed to shut off their lights, including the Versailles condominium, which had the most severe lighting problem, according to the biologists.

"Sure, we can cut them off," Versailles Manager Warren Jackson said. "We didn't know they were a problem. We certainly like turtles and want to keep them around."

Jackson said the lights, which were shut off Friday night, are for security purposes.

Ehrhart said bright street lights, parking-lot lights or large spotlights are the problem, not "lamps in windows." He said a good rule-of-thumb is that if a light

casts a shadow on the beach, it is too bright.

Ehrhart and fellow researcher Paul Raymond also plan to do further studies documenting how lights deter mother turtles from nesting. With a recently purchased light meter, the two biologists plan to compare nest concentrations under various lighting conditions.

"We are seeing a trend that bright areas, which are disastrous for hatchlings, are also bad for emerging adult turtles," Raymond said. "I think the light is distractive to turtles. They're night nesters."

Ehrhart points to decreased nesting activities on brightly lighted Central Brevard beaches compared to the darker beaches in South Brevard and Playalinda Beach. He admits there is skepticism about this theory among biologists because turtles have been found nesting under bright condominium lights and even in daylight.

But Ehrhart and Raymond aren't deterred by what they refer to as exceptions, and say that studying overall trends will bear out their theory.

"There's no reason to believe there wasn't as much nesting in Cocoa Beach and Cape Canaveral as the other areas in the old days," Ehrhart said.

Raymond also has diagnosed another threat to turtles — beach renourishment projects.

During a Melbourne Beach-Indianalantic project two years ago, 540,000 cubic yards of sand were dumped on the eroded beach strip in an effort to rebuild and widen it.

The first-of-its-kind study on the impact of the project on turtles, funded by the U.S. Army Corps of Engineers, has shown fewer turtles nested on the beach after the project. It also demonstrated that a number of turtles that attempted to nest on the beach couldn't dig holes in the compacted sand.

About 72 percent of the turtles who came up on the beach left without laying any eggs, the study shows. On a normal beach this figure runs between 45 and 55 percent.

But the dumped sand practically all has washed away over the past two years and turtle nesting is again approaching normal in the project area, the figures show.

A third threat facing the nursery comes from people — often well-intentioned turtle watchers — who scare nesting mothers. Ehrhart advises any person seeing a turtle to stay away until the turtle is done digging its hole and is well into the egg-laying process. Then the turtle can be approached quietly, but observers should not shine lights or take flash pictures until the creature is done laying its eggs and has begun covering them.

Editorials

TODAY

"Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech, or of the press; or the right of the people peaceably to assemble, and to petition the government for a redress of grievances."

—First Amendment to the U.S. Constitution

Vince Spezzano
Publisher

Buddy Baker
Executive Editor

Nick White
Editorial Page Editor

Lights on south beaches imperil sea turtles

One of the responsibilities nature has thrust upon Brevard County residents is the task of safeguarding the sea turtles that wallow onto our beaches to lay their eggs.

The coastline in South Brevard is perhaps the most important hatching area in the country for South Atlantic sea turtles.

Unfortunately, only in recent years have the turtles received the public attention they deserve. As with many other animals, they were allowed to sink perilously close to extinction before efforts began to reverse that trend. At this late date, whether the remaining turtles species can be saved remains to be seen.

Development of the beaches is a major threat to the turtles. Nesting sites are sometimes destroyed as buildings are constructed, and after those hotels and condominiums are built the bright lights they use often are fatal to hatchlings.

When they are born, turtles have a built-in ocean detector that apparently is triggered by light from the moon and stars reflecting off the waves. If this sensory system is confused by bright lights from streetlights, highways and

beachside buildings the turtles become disoriented and crawl the wrong way. Each year dozens are found squashed by cars or baked to death on hot pavement.

Obviously, it is unrealistic to expect beach development to stop out of concern for sea turtles, but ways can be found to allow the animals to share the shore. One of the simple ways people can help is to turn off bright outside lights on the beach during the nesting season from July to October.

Many condominium owners in Brevard already have taken this step voluntarily, but if volunteerism is not successful county officials have the option of passing an ordinance to ensure the lights are turned off.

Other modifications such as hoods for streetlights along the south beaches also are advisable.

As we have learned more about our coastal environment it has become evident that only through a concerted effort can we save the resources we once took for granted. Sea turtles, although awkward on land and far from beautiful in the conventional sense, are among those resources and worthy of our protection.

Lights doused to save baby turtles

By MIKE THOMAS
and DAVID DICKERSON
TODAY Staff Writers

Rising to a call to protect baby sea turtles, beachfront businesses, condominiums and at least one city are dimming lights at night so the hatchlings can find their way to the ocean.

In addition, Brevard County Commission Chairman Joe Wickham said he will propose a resolution at the commission's Thursday meeting encouraging beachfront property owners to turn off lights during the crucial nesting season of July through October.

A TODAY story Monday reported the findings of University of Central Florida biologist Lew Ehrhart that lights on the South Brevard beach, which is the country's largest turtle nursery, confuse the baby turtles and lead them to their deaths. The hatchlings are guided to the ocean after emerging from their nest by the reflection of the moonlight on the water. But moonlight can't compete with artificial lights.

"The beach is a darker place down here," Ehrhart said Tuesday. "It's a crowning achievement for sea turtle conservation in this area. You can guarantee it will help preserve turtles."

Wickham said he hopes to find a seashore expert to

'The beach is a darker place down here. It's a crowning achievement for sea turtle conservation in this area. You can guarantee it will help preserve turtles.'

**—Lew Ehrhart,
biologist**

discuss the problem with the county commission Thursday in an effort to generate "enthusiastic support" for a resolution.

"The ordinary person doesn't realize this is happening," Wickham said. "The mortality rate on those poor rascals is already unbelievable. The sea gulls eat them like peanut shells."

The light problem also has generated responses from some beach cities.

Indian Harbour Beach has asked Florida Power & Light Co. to shut off two street lights at the oceanside Bicentennial Park for the next month, City Manager Richard Edgeton said.

Police Officer Diane Davidson suggested the action

after she saw four turtle nests in the area of the park, Edgeton said.

"We will try it for a month to see if there are any unknown problems with having the lights off," Edgeton said.

After the trial period, Edgeton said he will decide whether to turn off the lights each nesting and hatching season. There will be increased police surveillance at the park while the lights are out, he added.

FPL spokesman Charles Cruey said the company can't turn off street lights unless it is requested by the person who signed the contract for the light.

Usually, private homeowners requesting a light for security must sign a lease guaranteeing they won't ask to shut it off before the end of the year, Cruey said. If the light is put out earlier, a penalty fee is levied.

But there would be no penalty for someone who requested a light be extinguished to help turtles, if the light was ordered back on after the hatching season, he said.

In Indianantic, the beach boardwalk is strongly illuminated at night but the town council decided Tuesday not to extinguish the street lights because darkness in the area would encourage vandalism.

Civilization Dims Its Lights To Help Turtle Hatchlings

MELBOURNE (AP) - Bright lights are dimming at a number of beachfront condos, business places and city streets in a growing effort to help turtle hatchlings find their way to the sea.

The response by city and county officials, a power company and ordinary citizens comes shortly after a university researcher's discovery that baby sea turtles emerging from their beach nests often become disoriented because of bright lights on seaside buildings and roads.

Thinking they are heading out to sea, the infant turtles soon exhaust themselves, become dehydrated and die, says biologist Lew Ehrhart.

News stories describing Ehrhart's findings brought quick results from residents along the south Brevard County beaches, considered the country's largest turtle nurseries.

Chairman Joe Wickham of the county commission said he would ask the group to pass a resolution encouraging beachfront property owners to turn off lights during the crucial nesting season, July through October.

The city of Indian Harbour Beach asked Florida Power & Light Co. to shut off two street lights at the oceanside Bicentennial Park for the next month, City Manager Richard Edgeton said.

A spokesman for the utility, Charles Cruey, said the company would bend the rules a bit and honor requests that street lights be extinguished to help the baby turtles. The lights have to come back on after the hatching season.

Manager Warren Jackson of the Versailles Condominium readily agreed to turn off bright security lights there.

"We didn't know they were a problem," he said. Ehrhart, a professor at the University of Central Florida, was delighted by the response.

"The beach is a darker place down here," he said Wednesday. "It's a crowning achievement for sea turtle conservation in this area. You can guarantee it will help preserve turtles."

Wickham said he hopes to generate "enthusiastic support" among county commission members for his resolution.

"The ordinary person doesn't realize this is happening," Wickham said. "The mortality rate on those poor rascals is already unbelievable. The seagulls eat them like peanut shells."

Police officer Diane Davidson suggested that Indian Harbour Beach shut off the lights after seeing four turtle nests near the park.

"We will try it for a month to see if there are any unknown problems with having the lights off," said the city manager.

Officials at Indianantic decided they couldn't turn off lights on their brightly lit boardwalk because the darkness would encourage vandalism.

FIGURE 17

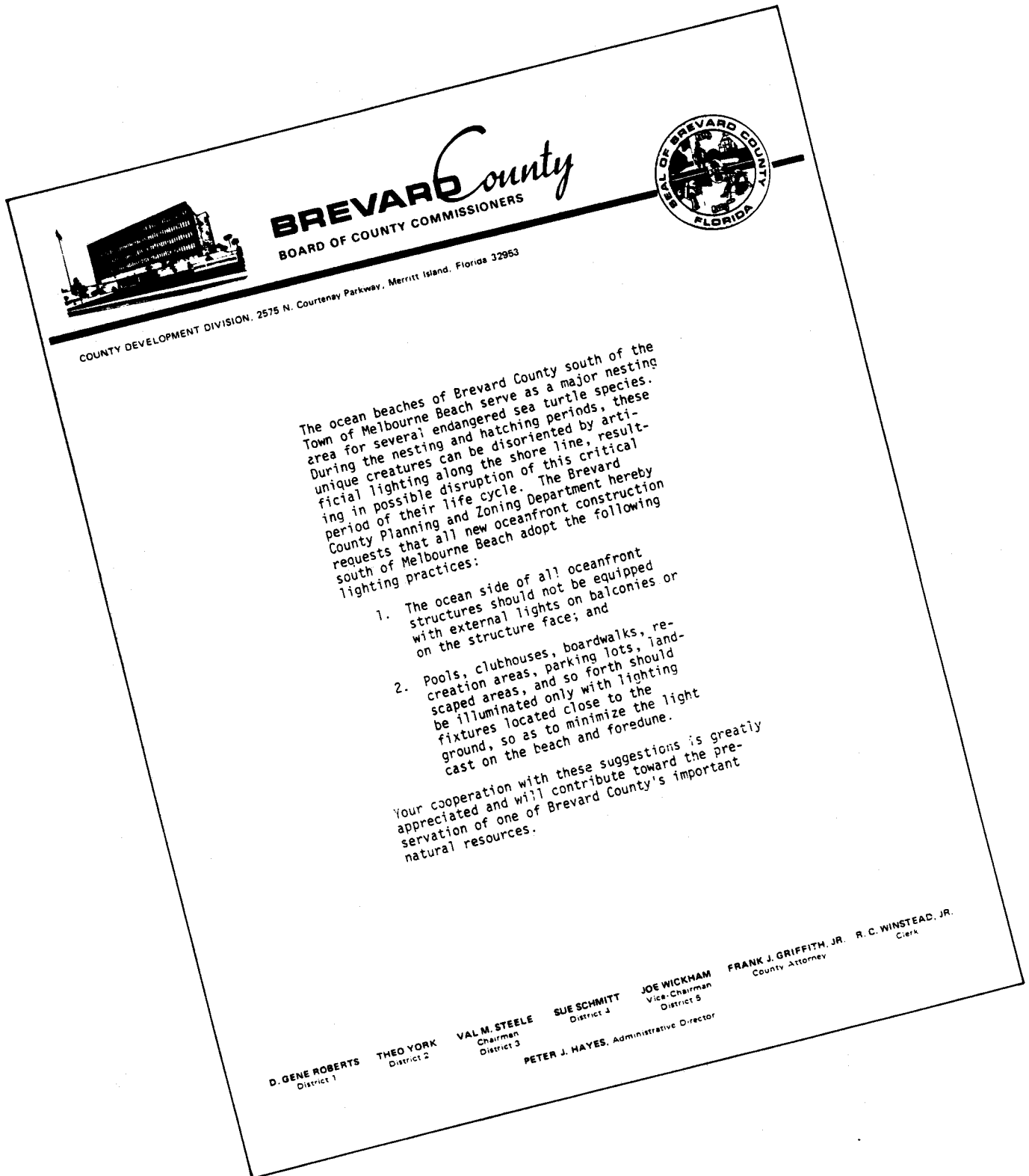


Figure 17

Notice to be distributed to new coastal developments in south Brevard County, Florida requesting reductions in beachfront lighting (from Scott Shuford, Senior Planner for the Planning and Zoning Department of Brevard County).

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