



COMPLIANCE WITH ENVIRONMENTAL GUIDELINES AND ORDINANCES REGARDING GREEN, LOGGERHEAD, HAWKSBACK, LEATHERBACK AND OTHER SEA TURTLES

Overview:

One of the most significant considerations in designing waterway lighting is its potential impact upon marine wildlife that includes turtles, fishes, marine mammals, and birds. In particular, the breeding cycles for sea turtles may be adversely affected by shore lighting that might interfere with visual cues associated with locating beachheads. Port-Bright™ lighting is specifically designed to address these issues by “tuning” spectral output to avoid frequencies that are more likely to attract marine life such as sea turtles. Port-Bright™ lighting emphasizes aspects of visual acuity that are unique to human vision. In addition, lamp geometry, reflectors, glare shield and lenses minimize light pollution.

Sea Turtles – An Endangered Species:

The global community has generally recognized that sea turtles are an endangered species. Modern maritime activities, urban development and human consumption are directly responsible for declines in sea turtle populations. From high-yield fishing operations to dredging... coastal construction to shipping and recreational boating, a serious toll has been taken on the sea turtle population. Today, there are more than seventy international laws protecting sea turtles. Most coastal states within North America have operational, zoning, and behavioral guidelines designed to protect sea turtle populations.



Among the various regulations are rules governing artificial light that may attract sea turtles to dangerous shoreline regions or disrupt instinctive behavior associated with breeding cycles. In particular, Florida has adopted ordinances pertaining to artificial lighting that may influence sea turtle behavior (Ordinance 2009-040 inclusive). These include:

- Restrictions on the use of lighting with peripheral “bleed” and the requirement for “full cut-off” fixtures that limit unintended peripheral illumination;
- Restrictions on the use of filters to limit lighting intensity and/or color spectrum;
- Specific limitations on spectral wavelengths below 570nm (blue to violet and ultra-violet range);
- Restrictions on directional lighting.

It is important to note that Florida's wavelength limitations (spectral output requirements and limitations) specifically **exclude** metal halide, halogen, fluorescent, mercury vapor and incandescent lamps, yet virtually **all** existing port, harbor, marine terminal, and waterway lighting currently falls within Florida's restricted categories. Port-Bright™ lamps employ spectral tuning technology so their photopic contribution within the visual acuity of sea turtles is the lowest compared to HID and other high intensity lamps. Thus, Port-Bright™ fixtures will provide the least disturbance to turtles.

Florida is, by no means, unique in its restrictions upon shoreline lighting. From Maine to Texas to California, light pollution has become a paramount concern.

The Lighting Regulation Paradox:

In direct contrast to guidelines and ordinances designed to protect marine life, the Occupational Hazard and Safety Administration (OSHA) has enacted minimum lighting requirements that would be virtually **impossible to satisfy** in conjunction with ordinances such as Florida's 2009-040 inclusive. For example, according to United States Coast Guard (33 CFR 126.15(1) and (n), and 33 CFR 154.570), general construction area lighting for working and walking areas shall be illuminated with a minimum of **5 foot candles on the ground** for ports and marine terminals involved in cargo transfer. Until the development of Port-Bright™ lighting, the only lamps that could meet OSHA and Coast Guard requirements were those banned by Florida's Ordinance 2009-040.

This is the dilemma that was addressed by Ultra-Tech™ lighting in creating the Port-Bright™ lighting product line.

Spectral Sensitivity of Sea Turtles:

The most extensive work to date involving spectral of sea turtles is reviewed in the *American Society of Ichthyologists and Herpetologies* 2004 article, Photopic Spectral Sensitivity of Green and Loggerhead Sea Turtles; D.H. Levenson, S.A. Eckert, M.A. Crognale, J.F. Deegan, II, G.H. Jacobs. The article abstract states:

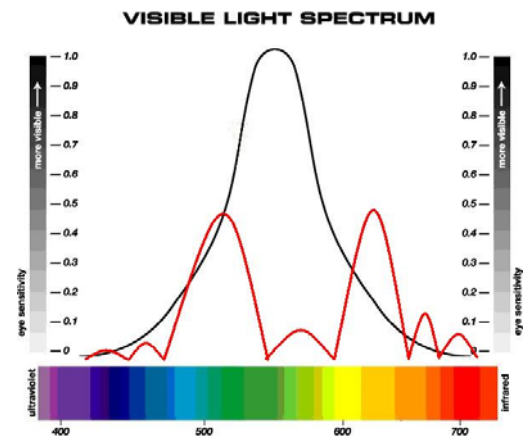
“Flicker electroretinography (ERG) was used to examine the in situ photopic (cone photo receptor based) spectral sensitivities of Green and Loggerhead Sea Turtles. Both species were responsive to wavelengths from **440-700nm**, and both had peak sensitivity in the long wavelength portion of the spectrum (**~580nm**). For Loggerhead Sea Turtles, no measurable responses were obtained **below about 440nm**, whereas reliable signals were seen for Green Sea Turtles at **wavelengths down to 400nm**. Both species exhibited significant declines in sensitivity **below 500nm**. The overall shapes of the spectral sensitivity functions were similar for the two species. These results support previous findings that sea turtles have well-developed **photopic visual systems**. The characteristics of these spectral sensitivity functions indicate that both species possess multiple cone photopigment types, and these, in conjunction with the presence of colored oil droplets, strongly imply a capacity for color discrimination. Comparative evaluation suggests that these turtles have modified their visual pigments from those of their terrestrial relatives to better suit the ambient conditions present in the shallow water, submarine environments that they typically inhabit.”

These findings provide a foundation for the turtle-friendly Port-Bright™ tuned spectrum. The *unfortunate reality* is that the science directly conflicts with Florida’s ordinance banning light below 570nm while emphasizing spectral output *specifically found to be within turtle’s maximum visual acuity*. By altering phosphorous absorption/conversion formulations in MIL bulbs, and by varying ballast frequencies, Port-Bright™ fixtures attenuate wavelengths that are **most visible** to turtles while balancing the spectrum most effectively used by the human eye known as “visually effective lumens” (VEL) or Pupil Lumens. The result is a relatively innocuous light source for turtles and highly useful and safer illumination for workers.

Since turtles have a different ratio of rods to cones, their sensitivity to luminance or the “brightness” of a Port-Bright™ lamp will be less than for people. It is this difference that allows Port-Bright™ fixtures to provide maximum visual effect for humans without substantially impacting turtles. There has been a general misconception that sea turtle hatchlings *require* a full moon to gain orientation. Empiric studies conducted on Naples, Florida beaches reveal hatchlings emerge during all phases of the moon. Since the moon provides polarized light at .27 lux, and intensifying to 1.0 lux toward the equator, it is unlikely that the moon’s luminance provides a primary orientation cue. Rather, the contrast between the white sandy beach surface and the seemingly black, light absorbing water may be instinctively used to find the ocean. Equally considered by researchers is the “flicker” of light upon the water’s surface. It is possible that the 60-cycle or 120-cycle strobe of traditional lighting such as fluorescent and even new LEDs is a primary source of confusion for hatchlings.

The Port-Bright™ Spectrum:

Using combined research findings, the Port-Bright™ spectrum achieves a balanced nearly full spectrum light absent wavelength intensities **found to attract and/or stimulate sea turtles**. Moreover, traditionally, light has been measured using photopic lumens which fails to account for *mesopic vision* that measures the actual light perception actuated by the interrelation between rod and cone cells under “intermediate light intensities” such as terminal lighting. Furthermore, humans see reflected light from observed surfaces known as *luminance* or “brightness.” Turtles may distinguish between land and sea by sensing only reflective contrast.

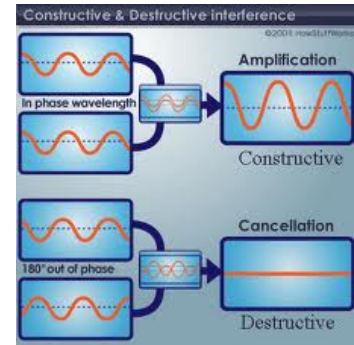


Test results show particular sensitivities at 520nm and 560nm with the greater emphasis at 560nm. Sensitivity below 500nm measured as fairly constant. The oil composition within the turtle’s eye appears to act as a filter from 400nm to about 440nm. The human eye exhibits a bell-shape sensitivity curve from 400nm to 700nm as illustrated in the graph. Port-Bright™ bulbs provide light across the entire visible spectrum with different intensities. Without using filters, appropriate light is directed out of the lamp enclosure using special white ultra-reflective materials to further refine the spectral output and avoid “hot spots.”

To create “Turtle Safe™” lighting, Ultra-Tech™ Lighting can use a unique method of “constructive interference” in creating lighting layouts that act in the same way as noise-canceling headphones. When different light wavelengths are combined, they produce different colors and hues. Some frequencies are “complementary” while others are “destructive.” The specialized Port-Bright™

spectrum can take advantage of canceling properties within the spectrum to create lighting “voids” and reduce unwanted light dispersion.

No other lighting provides this design versatility to meet the rules and regulations ***head on!*** Port-Bright™ can generate in excess of 5.5 mesopic foot candles on the ground within the most sensitive ranges for human sight ***exactly where it is wanted*** with the appropriate photometric layout while being mostly unobtrusive to sea turtles. As an extra measure against light pollution, lamp geometry is specifically ***down-lighting*** with full cut-off lenses and Vari-Beam™ focal adjustment. Using angular off-setting, Port-Bright™ fixtures only direct light ***where it is intended***. As the diagram illustrates, Port-Bright™ fixtures intensify visual light where it is needed while canceling out undesirable wavelengths through the use of appropriate reflector and lens technology.



We know of no other lamp that can comply with both OSHA and U.S. Coast Guard lighting requirements while addressing rules, regulations, and guidelines designed to protect against light pollution that may adversely impact the behavior of the full range of sea turtles and other marine wildlife¹.

Sustainability:

Simply put, Port-Bright™ goes beyond the highest expectations of port and marine facility operators with ***energy savings of up to 70%*** over HID, halogen, fluorescent, mercury vapor, and incandescent lamps. The extraordinary life-cycle of 100,000 hours operating 24 hours x 365 days translates into more than a quarter of a century of maintenance-free operation for savings over conventional lighting exceeding 600%.

Finally, Port-Bright™ fixtures can be completely recycled. The mercury is encapsulated in a removable “slug,” making the remaining fixture safe for disposal as glass and metal.

WHEN IT COMES TO PROTECTING THE ENVIRONMENT, NOTHING WORKS BETTER THAN PORT-BRIGHT™ LIGHTING!

¹ Unique Port-Bright™ technology is able to meet OSHA and Coast Guard regulations and address the perceptible spectrum of turtles and other sea life by concentrating upon “Pupil Lumens.” It is important to understand the principles behind visible light and lighting intensities as follows:

- Luminous flux/Light output – The amount of light produced by a lamp. It does not take into consideration the direction in which the light is sent. Most lighting devices produce light in a 360 degree sphere. This light must then be redirected by a set of optics to the area where it is needed. Light output is measured in lumens.
- Illuminance/Light level – The amount of light incident on a surface. It is measured in foot candles (FC) or lumens/square foot (One foot candle is equal to approximately 10.764 lux).
- Luminance/Brightness – The amount of light reflected by a surface. It is measured in foot lamberts or 3.426 Candela's per meter square.

The human eye sees luminance and is not concerned with luminous flux or illuminance. By specifically designing lighting as a ***synergistic system***, Port-Bright™ technology can address all aspects of waterfront illumination in an energy-efficient, environmentally friendly, and highly sustainable manner.