The Effects of Light Pollution on Sea Turtles: A Review of Behavioral and Physiological Implications

***Abstract*—This review study investigates the effects of light pollution on sea turtle settling and hatching success. Bright lights dazzle hatching's, making them easy prey for hunters or disorienting them in urban areas, resulting in lower endurance rates. Female sea turtles also exhibit changes in settling behaviours, such as avoiding appropriately light areas and choosing less-than-ideal settling spots, which can have an adverse effect on population development. Controlling lighting rehearsals and establishing safe zones for sea turtle settlement are two feasible planning methods for reducing the influence of light contamination. The study's findings highlight the urgent need for action to eliminate light pollution and protect and sustain sea turtle populations.**

***Index Terms*—Light pollution, Sea turtles, Settling success, Hatching success, Bright lights, Predation risk**

I. Introduction

The issue of light pollution is becoming more prevalent, impacting diverse organisms such as sea turtles. Sea turtles are incredible creatures that have existed for millions of years. However, they are currently facing a slew of threats that are pushing them to extinction.One of the biggest threats to marine turtles is light pollution, which is raising concerns among academics, conservationists, and lawmakers. Artificial light produced by human activity that messes with the natural cycles of day and night is known as "light pollution." Sea turtles' behaviour and physiology may be harmed by light pollution, which may cause them to get confused, leave their nests, or have irregular periods of migration, eating, or reproduction. Due to confusing hatching, interfering with normal behaviour, and altering nesting areas, sea turtles have suffered detrimental effects. Studies focused on the physiological, behavioural, and ecological consequences of artificial illumination have increased in recent years, which has led to an increase in interest in how light pollution affects sea turtles. The purpose of this review article is to offer a complete summary of existing information on the impacts of light pollution on sea turtles. We will investigate the processes behind the effects of light pollution, the scope of the problem, and the efficacy of mitigation solutions. We believe that by summarizing the current knowledge, we may increase awareness of this critical issue and help develop successful conservation measures for sea turtle protection.

II. Behavioral Effects of Light Pollution on Sea Turtles

The article [1] discusses how light pollution affects the behaviour of sea turtle hatching. These hatchings rely on visual cues, including the intensity of light and relief elevation, to orient themselves towards the ocean. Thousands of hatchings perish annually as a result of issues like dehydration and predators owing to the disruption of their natural orientation caused by the growth in artificial illumination on beaches brought on by tourism and development. The use of artificial lighting is still common despite the fact that Brazil's Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) has issued Ordinance 11 to forbid its use on beaches where sea turtles lay their eggs. The goal of the study was to determine how the hatching capacity to self-orient is affected by artificial light sources and moon phases. Ipojuca was the study's location, Pernambuco, Brazil, and the data was collected with permission from the ICMBio under authorization number 22741-1. The study included ten experiments with 15 hatching per test, randomly selected from 10 nests, and was conducted between March and May 2012.

The paper [2] talks about how artificial light affects sea turtles. It clarifies that sea turtles avoid beaches with a lot of artificial light, suggesting that the light frightens them. The light can also confuse them, especially during the nesting and hatching periods when they rely on natural light to find their way. This confusion can lead to more turtle deaths as hatching may head towards land instead of the ocean. Many coastal areas have enacted laws to reduce light pollution during sea turtle nesting periods.

The paper [3] discuss hatching behaviour is negatively affected by light pollution resulting in increased mortality according to findings from the study. Due to artificial light sources, leatherback turtle hatching crawled in the wrong direction and headed towards the light source. Also, they failed to orient themselves towards the ocean resulting in abnormal behaviours. As per the investigation carried out by the researchers it was discovered that hatchings might undergo disorientation and dehydration due to light pollution exposure. This can heighten their vulnerability to mortality. The probability of hatching's reaching the sea is decreased when they crawl towards vegetation or obstacles due to exposure to artificial light sources thereby increasing their risk of dehydration or predation. In addition, according to the research conducted, being exposed to artificial light may impact the baby turtles' internal clock which can lead to decreased swimming movements and modified metabolic rates. Long-term impacts on populations could result from these effects, impacting the

overall health and survival of hatchings. The study implies that light pollution can have significant behavioural consequences for leatherback turtle hatchings. Protecting these endangered species requires reducing light pollution on nesting beaches through the use of low-intensity lighting, shielding lights and limiting unnecessary lighting in coastal areas.

This paper [4] discuss Visual cues like brightness and beach silhouette help sea turtles locate the ocean. However, it is light that serves as their primary guiding cue. hatching and adult marine turtles can become disoriented by artificial lights. Beach furniture entanglement or road collisions with vehicles have resulted in the death of some adult marine turtles. The presence of light pollution causes sea turtle hatchings to become disoriented. According to studies conducted on this issue. Delay in reaching the ocean lowers a hatching's fitness and survival ability. Unlike their counterparts that were exposed to brighter surroundings and less inclined towards direct movement into the ocean, hatching placed in dark environments showed a greater tendency for rapid movement into the ocean. Light pollution can lead turtles away from the sea and towards danger by confusing and disorienting them. It is worth noting that hatching's that were exposed to high levels of artificial light displayed unsteady crawling behaviour. Some turtles even moved around the light source or went in the opposite direction. Their struggle to navigate towards the ocean may be attributed to a disturbance in their natural cues which depend on the relative positions of both moon and the horizon. Artificial light can impact the nesting behaviour of female turtles as well. To navigate to and from their nesting sites successfully, female turtles depend on the light of the moon. By interfering with turtle behavior and causing disorientation artificial lights can lead to decreased nesting success. Turtles' foraging behaviour in the water can be impacted by light pollution as well. Positioning themselves with respect to sunlight and polarized light helps sea turtles navigate and locate their prey. Artificial lighting can interfere with natural turtle cues leading them to become disorientated which results in a decrease of successful foraging attempts that could ultimately lead them towards starvation.

This paper [5] says A critically endangered species, loggerhead sea turtles are disappearing from the planet at an alarming rate. Shoreline development had contaminated over 98% of ocean turtle populations and surrounding habitats. The critically endangered Loggerhead turtle, Caretta, is one of the many kinds of ocean turtles, and it is known to be readily misidentified. Loggerhead sea turtles, the second-largest species of ocean turtle after leatherbacks, can weigh up to 1,000 pounds. It is challenging to disregard elements like light pollution that are causing this drop given that the number of Loggerhead sea turtles has decreased from millions to an estimated 50,000. By 2060, the United States Southeast region is anticipated to be 139% more urbanized. South Carolina beaches will have expanded by 261% by 2060, the most of any urban area. Hatcherhead sea turtle hatching on Hilton Head Island can't find the water because of artificial light from nearby resorts. Light pollution, artificial or unnatural illumination, and other factors have a negative impact on the dietary patterns, health, regeneration capability, and predation rates of ocean turtles.

The paper [6] discusses Light pollution is a concern in Puerto Rico because it harms the biological systems along the coastline, including sea turtles and other marine life. When returning to the sea from the shore, sea turtles rely on the moon and stars for natural light. When there is no artificial lighting present, the moon reflecting off the lake appears to be the most brilliant object. In any case, there are some locations in Puerto Rico that are close to the beaches and have a lot of artificial light, which deters turtles from swimming in the ocean. Female sea turtles seek out the most distant and calm areas to lay their eggs when nesting. They grow concerned when there is too much artificial light near the water and seek out alternative seashores, even if they are not the best. As a result, there may be fewer or no eggs laid. Light pollution has a substantial negative influence on hatching because they seek the most appealing item when they leave their nests, which is usually the moon and stars reflected in the water. The hatchings may become disoriented if there are several sources of artificial light. They can end up attempting to flee to the lights and perish from exhaustion, dehydration, earthly predators and running cars. The Assessment and Educational Outreach of Lighting Practices for Coastal Light

According to this paper [7] Light pollution's behavioural impacts on sea turtles are mostly connected to their nesting habits. Artificial illumination on nesting beaches can create confusion and misorientation in nesting females and hatching, causing them to flee to risky regions away from the sea. This can lead to weariness, thirst, and predation if they become caught in holes, obstructions, or vegetation. Furthermore, artificial light can disrupt communication between females and males during mating, reducing the population's reproductive success. Overall, the behavioural consequences of light pollution on sea turtles can have a major detrimental influence on their survival and reproductive success, making effective mitigation techniques critical.

The article [8] says Artificial nocturnal lighting has the potential to disrupt the circadian rhythms of sea turtles, which can have an effect on their physiological processes such as hormone production, sleep, and metabolism. For an organism's biochemistry to be in sync with its nocturnal activities, there must be a contrast between day and night. The circadian rhythm can be thrown off if there is an imbalance between the body's internal biological clock and its surroundings, such as nighttime lights, which could have an impact on sea turtle populations' ability to survive. One posited underlying reason for the ecological consequences of artificial night illumination is the inhibition of melatonin production at night, a crucial regulator of biological rhythm and a potent antioxidant altering immune function.

III. Physiological Effects of Light Pollution on Sea Turtles

The paper discusses [1] Sea turtle hatching use a process called phototaxis to orient themselves toward the ocean based on the amount of light and the elevation of the surface. This natural process has been hampered by artificial light pollution on beaches, causing hatchings to become lost and unable to find their way to the water. On the southern coast of the Brazilian state of Pernambuco, an investigation into the effects of artificial light on sea turtle hatching's of the species Eretmochelys imbricata (Linnaeus, 1766) was conducted. In the study, ten tests were carried out, with 15 hatchings per test subject. Five of the experiments were conducted in artificially lit locations, and the other five were conducted in dark areas. To see if the trajectories varied between the two groups, the hatching was placed in a little depression in the sand to mimic emerging from a nest. Their footprints were then taken and plotted on a diagram. Using the Rayleigh test and ANOVA, it was determined whether the differences between hatching from lit and unlit nests were significant. Additionally, multidimensional scaling was employed to assess cluster significance and similarity.

The study discovered that 86.67% of hatching from nests in lighted locations diverged from their intended course, with the distribution of trajectories for tracks coming from artificially illuminated areas being considered random. Two unique groups of hatching's, one from lighted areas and the other from non-illuminated areas, were recognized based on their varied movement patterns. The study found that artificial lighting affects the direction of hawks-bill hatching's and contends that protecting this species' nesting grounds from artificial lighting is essential.

For turtle hatching's, artificial lighting can lead to a number of issues, including dehydration, increased predating, and death. hatching's may already be severely compromised by the time they get to the water despite the stimulus from artificial lighting, which lowers their odds of survival. The number of sea turtles has decreased as a result of these effects, along with other Anthropocene interference such fishing operations, pollution, and the destruction of nesting habitats. All sea turtle species are now classified as either endangered or threatened, and protective measures must be done to keep them from being harmed by light pollution.

Sea turtles require virgin beaches with specific physical traits for breeding, and this paper [2] does call attention to the fact that human activities like population increase, tourism, and development have led to a drop in sea turtle nesting areas in the Caribbean. This decrease in nesting sites is anticipated to have a severe impact on the number of sea turtles and the marine ecosystems where they are essential to ecological health.

The paper discusses [4] Increasing metabolic rates and decreasing activity levels are effects on loggerhead sea turtle hatching's when they are exposed under artificial light, which was revealed by the research. The turtles' response to perceived daylight likely causes an increase in metabolic rates and energy consumption. It's possible that confusion over the location of the ocean and an inability to orient themselves correctly have caused a decrease in activity levels among turtles. In general, the research indicates that sea turtles can experience noteworthy physiological impacts from light pollution, particularly in terms of their metabolism and behavior. Sea turtles' survival rates and ability to reproduce could face long-term impacts from light pollution, making it necessary to manage and decrease this problem in coastal nesting areas.

In this paper [5] it discusses Sea turtles are unable to escape places with light pollution because they have been seen returning to the ocean side where they lay their eggs. The turtle will then dig a burrow for the eggs, conceal them again, and hide the house from any approaching hunters. Females lay three to five nests with approximately 100 eggs per season. The mother makes a beeline for the water after each egg is laid and completely covered, and she does not return until the next settling season. The mother stands towards the ocean, using the light reflected off the waves. The hatching's often exit the nest at the same time to increase their chances of surviving against predators. Visual cues, such as the twilight glow around evening time falling off the sea, are vital for them to find the sea, much as how adult female sea turtles use moonlight after landing. They look for the most beautiful skyline at the best price, but occasionally, artificial light slows them down and reduces their stamina. The hatching's try to find their way to the sea when this happens because they are bewildered. But after a while, they choose to go in the direction of the brightest source of light, which is usually inland.

According to this paper [6]Light pollution has various impacts on different species, including sea turtles. It creates an ecological trap for moths, which can affect the interaction between different species. Sea turtles are affected by light pollution because the hatching's become disoriented when they move towards sources of artificial light such as roads, increasing their mortality rates. The darkness and shadows created by grasses and bushes inland are visual cues for hatching's to move towards the ocean. When artificial lighting eliminates these cues, hatching's get confused and move towards harmful sources of light. Female sea turtles avoid well-lit areas when they arrive onshore to nest, instead preferring darker areas. Because the temperature of the sand as a whole determines the sex of turtles, continuous light beaming on sand patches may disrupt the distribution of sexes. Light pollution can disrupt the normal balance of sex ratios in sea turtle populations by warming the sand and boosting the amount of female hatching's. Promoting public awareness of the negative effects of light pollution on sea turtle ecosystems is essential. By reducing light pollution, we can help sea turtles and other species thrive and maintain a healthy environment.

In Coastal light pollution and marine turtles:assessing the

magnitude of the problem article [7] assess how serious this issue is for marine turtles while also mentioning its physiological effects in brief. Authors suggest that sea turtles' regular biological rhythms and behaviors like nesting and hatching orientation may get disrupted due to exposure to artificial light at night. Besides that point, it should be noted that excessive lighting from human activities can lead to physical stress for animals like sea turtles by affecting their immune system while also hindering their growth.

The paper [8] discuss Sea turtle hatching's use the slope, color, and form of the beach as natural landmarks to direct them in addition to starlight or moonlight. However, hatching's may become disoriented at night due to artificial lighting, which could increase the likelihood that they will die from exhaustion, thirst, or predating. Because they make hatching's ignore slope cues and turn their heads toward the brighter inland light, powerful artificial lights alone in Florida kill thousands of hatching's every year and lower population viability. High rates of disorientation in hatching's have been documented in numerous parks, underscoring the necessity for careful planning to control lights and safeguard sea turtle populations.

IV. Mechanisms of Light Pollution Impact on Pattern Recognition in Sea Turtles

Discussed in the paper [1]that The main orienting processes that help sea turtle hatchings find the ocean in abiotic natural conditions are mostly related to light intensity and relief elevation. However, the presence of artificial lights brought on by human activities, such as tourism and coastal artificial lighting, has a detrimental effect on the survival rates of sea turtle neonates by making it harder for them to move around. A study was carried out to determine the effects of artificial illumination on sea turtle Eretmochelys imbricata hatchings on the southern coast of the Brazilian state of Pernambuco. Ten tests comprising 15 hatchings were conducted for the study, five of which took place in well-lit surroundings and five of which did not. To represent their exit from a nest, the hatching was placed in tiny depressions in circles on the sand with a 2 m radius. Their steps were recorded on camera and mapped on a schematic as they left the rings. According to the findings, there were observable differences between the movement patterns of lighted and non-lit areas, and 86.67% of the hatching's from lit locations departed from their intended trajectories. The study comes to the conclusion that nesting locations need to be protected from artificial lighting in order to preserve the species and that artificial lighting affects the orientation of hawks-bill hatching. The stimulation from artificial lighting, which is more powerful than that from natural light and affects them even after they reach the water, weakens hatchings. Additionally, they cause dehydration, raise mortality, boost predating, and reduce energy requirements for the first few hours of swimming. The number of sea turtles has decreased as a result of artificial lighting and other man-made interference, including fishing operations, pollution, and the degradation of nesting habitat.

The effects of light pollution on sea turtles' capacity to perceive patterns are concerning since they could lead to confusion in both hatching and adults. Light pollution can impair the navigational abilities of sea turtles by interfering with their natural inclination to follow the moonlight's reflections on the water's surface. This can cause hatching to crawl towards artificial light sources rather than the water, which can be disastrous, and adult sea turtles are unable to return to the ocean after nesting. According to the article [2], the increased lighting may interfere with the visual cues that sea turtles use to recognise their natural habitat. However, the article makes no specific assertions regarding how light pollution affects sea turtles' pattern recognition. Moreover, light pollution can alter the natural reproductive and migration patterns of sea turtles, as well as their circadian rhythm. To protect sea turtle populations, it is essential to restrict artificial lighting near reproductive areas and implement lighting control strategies.

According to this research [5], housing on Hilton Head Island's seafront will influence how quickly hatching Blockhead sea turtles reach the water. This has an effect on their ability to find water after birth. Adult South Carolina Blockhead sea turtles have been observed travelling north and south along beaches, according to some research. Whatever the reason, it was unknown why some of their comrades chose to walk north rather than south. That provides an explanation for the heritable differences between these turtles and their distinctive movement patterns. Researchers urge that preservation efforts and plans of insurance for the animals be expanded to these more northern regions because these relocation plans are not usually recognized.

This paper [6] discusses Artificial lighting has become a significant problem for sea turtles. It disorients hatchings by eliminating the natural cues they use to find their way to the ocean, leading them towards harmful sources of light. The hatchings can become disoriented and move towards areas with higher light levels such as roads, which can increase their mortality rates. When female sea turtles arrive onshore to nest, they prefer to nest in darker areas. Light pollution can lead to warmer sand, which produces more female hatching, altering the natural balance of sex ratios in sea turtle populations. Female sea turtles are also sensitive to light when nesting and prefer nesting in darker areas. Bright lights can disorient them and make them more vulnerable to predators, which can harm the population. Therefore, it is important to raise awareness about the impacts of light pollution on sea turtle ecosystems and promote sustainable lighting practices to mitigate these effects.

The paper [7] explain the methods by which light pollution might impair pattern recognition in sea turtles in their work "Coastal light pollution and marine turtles: Assessing the magnitude of the problem." One method is the changing of light's spectral makeup, which might interfere with the visual

signals used by turtles to navigate to and from nesting places. The presence of artificial light, in particular, can create a change in the ratio of green to blue light, impairing sea turtles' capacity to sense the polarization pattern of light across the ocean. This pattern is essential for effective navigation, and disturbance of this perception can result in confusion and inability to locate or return to nesting locations. Another way that light pollution affects pattern recognition in sea turtles is by disguising natural light signals. brightness pollution can generate a level of brightness in the background that overpowers the weaker, natural light signals that turtles rely on for navigation. Artificial light, for example, can interfere with hatching sea turtles' ability to orient themselves towards the brighter horizon, which they use as a visual signal to steer them towards the ocean. Instead, the hatching may be drawn to artificial lights, which may take them away from the water and into danger.

Adult female sea turtles are deterred from nesting on beaches by artificial lights having spectral peaks between 400 and 700 nm.According to this paper [8] Due to this, there are more false crawls, fewer hatchings emerge, more depredation, nest damage, and predating. When nesting, marine turtles prefer darker beaches and steer clear of bright areas more so than those that are dimly lit. Artificial lighting on a beach can prevent and deter turtles from coming up from the water at night. Night lighting increases the possibility of direct human influence and may cause nesting efforts to be abandoned or egg deposits in the water.

V. Mitigation Strategies for Light Pollution in Sea Turtle Habitats

A haws-bill turtle hatching's reaction to artificial light is examined in this study [1] along with how hatching moves toward the ocean. Ten trials with 15 hatchings each were run along the southern coast of Pernambuco state for this inquiry. The studies were carried out in two equal halves, one in locations with artificial lighting and the other without. On the sand, two-meter circles with a 2-3 cm dip in the centre were drawn. The neonates were then inserted into the craters to represent the hatching emerging from a nest. The hatching exit routes from the rings were documented in pictures and on a schematic. The trajectories of the hatching in the two groups were compared using the Rayleigh test, and any differences were assessed for significance using ANOVA. The similarity and relevance of the clusters were assessed using a multi-dimensional scaling method.

Only tracks from artificially illuminated locations were found to exhibit random distributions of trajectories, according to the data, and 86.67% of the hatching's from lit-up nests had tracks that diverged from their intended routes. Based on the movement patterns of hatching from luminous and unlit areas, two distinct groups were identified: one from bright areas and the other from unlit areas. The orientation of haws-bill hatchings is negatively impacted by artificial illumination, hence it is essential to shield nesting places from this type of lighting in order to preserve this species. The essay also highlights the fact that, despite Ordinance #11 of the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) prohibiting the use of artificial lights on beaches where sea turtles nest, their use is still pervasive and is the cause of the annual deaths of tens of thousands of hatching haws-bill, green, and loggerhead turtles. For example, dehydration, increased mortality and predation, and a lack of energy for their initial few hours of swimming are all issues that turtle hatching face under artificial lighting. The number of sea turtles has decreased as a result of these consequences as well as other anthropogenic interference such as fishing operations, pollution, and the destruction of nesting habitats.

The paper discuss [2] Reducing human impacts on reproductive sites is essential for the survival of sea turtle populations. Light pollution is a significant threat because it interferes with the natural behaviour of sea turtles, particularly hatching that use the moonlight to navigate to the ocean. Light pollution is also associated with disorientation, which causes hatchings to migrate away from the sea and towards other light sources, such as buildings, which increases the risk of mortality due to dehydration, predating, and vehicle collisions. There are a variety of ways to mitigate the effects of light pollution. Long-wavelength red light lamps are an option because they have no effect on the behaviour of sea turtles, which cannot perceive long-wavelength light. During the nesting season, shades, drapes, or blinds may be installed on windows that face the beach to reduce the quantity of light that reaches the beach. Communities can also partake in light pollution reduction campaigns, such as the "Lights Out" initiative, which encourages the reduction of outdoor lighting during sea turtle nesting season.

In the case of Armila Beach, Panama, the Guna have passed legislation outlawing light pollution, especially during the nesting season, and mandating the use of red lights by anyone wishing to view sea turtle nesting and hatching. Due to these efforts, the leatherback sea turtle population has increased significantly and its nesting environment has been adequately safeguarded. Therefore, implementing similar laws and strategies can mitigate the effects of light pollution on sea turtle populations at other nesting sites.

Here this paper [5] Costly mitigating measures will be taken to boost the number of Blockhead sea turtles on Hilton Head Island and, eventually, other marine species and sea turtles that are in danger. The two hotels that front the beach will have all of their windows covered in order to investigate the impact of less light pollution on these ocean fronts. All windows at Marriott Grande Sea with ocean views will have coloured exteriors. Since the shower is the most affordable and quickly applied option for window colouring, it will be used. The Marriott Westin's sea-facing windows' exteriors will all be painted. Sun-powered window film will be utilized to let in natural light while protecting against UV and infrared radiation, reducing energy use, limiting heat transmission,

and providing security. Normally, this movie runs for seven to twelve years. Changeability may obstruct this interaction throughout the window-colour establishment cycle. The company chosen to install these window colourations will be required to employ the same staff members every day, and each will be given a sector of windows to supervise colour usage, confining irregularity to the hotel's area. The least amount of room for error will be in this.

It is important to remember that Hilton Head has already put in place mitigating measures to help safeguard the sea turtles who visit its beaches. The configuration for the light sculptures necessitates the most maintenance. They predict that all outside lights will be turned off or covered by 10 pm every night until 6 a.m. throughout the settling and bring-forth season, which runs from May to October. It is also recommended that all blinds in dwellings be closed from 10 pm to 6 am during the settling and pregnancy seasons. Resisting is punishable by fines in town. This may influence the outcome of the review while demonstrating the town's current care for sea turtles. This rule protects sea turtles against artificial light in the area where the evaluation is being conducted, which may not be the case in other regions where the review may be repeated. In any case, it will also take into account whether extra efforts should be made to effectively reduce the levels of light pollution and sea turtle confusion over the long term. This does take into account a moderate approximation of perplexity nearby. The window colouring techniques used in this study along with this light statute are anticipated to have a significant impact on the achievement rates of sea turtle hatching's arriving at the sea as well as increase the Blockhead population on Hilton Head Island and ultimately settle locations around the world.

Here the paper's [6]goal was to evaluate lighting practices and improvements to reduce light pollution and provide educational support in order to protect ocean turtle nesting grounds on the beaches of Puerto Rico. To accomplish this, we divided our project into three main components: information and stock selection, overview distribution, and creation of an educational handout and guide as required. To investigate lighting practices, we measured light levels in Isla Verde with a photometer and a sky quality meter (SQM). The photometer was used to determine the power of a light, which was measured in foot candles (FC). The brightness of the light and the significance of light contamination both increase with reading altitude. The maximum perusing per property was 2.34 fc on average. The bulk of the lights were inconsistent when compared to the appropriate level anticipated by the guideline of 0.05 fc. Work 1 on Isla Verde measured the brightness of the sky with a sky quality meter. The measurements were taken in arcseconds per square inch (mesas), with the greater reading indicating that there was more light nearby. The average SQM perusing from 19 regions in stage 1 was 17.76 mesas. SQM measurements at Isla Verde have reduced dramatically when compared to the 2014 IQP group, which had an average value of 18.33 mesas. This demonstrates that light contamination has grown in recent years.

The paper [7] says that Light pollution may have serious consequences for sea turtles, especially hatching, by confusing them and diverting them away from the water. There are various ways that may be used to reduce the impacts of light pollution.Reducing the quantity of artificial light on the beach is one option. This may be accomplished by utilizing low-pressure sodium vapour lamps that generate light in the 580-590 nm range, which is less harmful to sea turtles. Shielding and moving light sources away from the beach can also assist. Another option is to put more space between light sources and the beach. This can be accomplished by relocating lights further away from the beach or raising the height of light fixtures. Lighting controls might also be put in place to limit the amount and intensity of artificial light on the beach. Education and awareness efforts can also help to reduce light pollution. These initiatives can serve to increase awareness about the effects of light pollution on sea turtles, as well as urge beachgoers and property owners to utilize turtle-friendly lighting.

Adult female sea turtles are deterred from nesting by artificial lighting on beaches, and this can result in false crawls when the turtles fail to dig a nest and lay eggs. Because turtles prefer darker beaches, nesting is prevented by lights with spectral peaks between 400 and 700 nm. Artificial light causes nests to be more concentrated on darker beaches, which can lower hatching emergence rates, increase depredation rates, and raise the likelihood that other nesting females will destroy a nest. Artificial illumination can also prevent turtles from leaving the water, reduce their nightly activity, and raise the possibility that direct human interference with nesting activities will cause the turtles to give up on their nesting efforts.

VI. Effectiveness of Mitigation Strategies

According to this paper [2] Their reproductive grounds must be protected in order for sea turtles to survive. An important leatherback sea turtle nesting location in Panama, Armila Beach, has suffered a drop in nesting sites as a result of human influences such as habitat degradation and bycatch from fishing.. The Guna of Armila has held an annual sea turtle festival in May since 2010 and has passed legislation prohibiting poaching and the devastation of nesting habitat. Since the establishment of these laws, the number of breeding tortoises has increased due to the efforts of the Guna people to preserve this nesting site (Nichols et al., 2014).

In addition to preserving reproductive sites, it is crucial for the conservation of these species to identify the qualities of beaches that sea turtles prefer. The Armila Beach's physical attributes, such as elevation, slope, sand type, and breadth, were assessed using the Nesting Beach Indicator to see if there was a relationship between them and the number of D. Coriacea nests found at different parts of the beach. In contrast to gravel or boulders, it was found that D. Coriacea strongly preferred to nest on sections of the beach where sand was the

major sediment type. According to Martinez et al. (2008), only beach width—not sediment type—was found to significantly influence the number of colonies already present.

The Guna people of Armila have successfully conserved the reproductive site of the leatherback sea turtle, and initiatives such as the sea turtle festival have contributed to the conservation of this species. In addition, the Nesting Beach Indicator can help conserve sea turtle populations by emphasising the preservation of these beaches.

According to this paper [3] Beach patrols are currently the most effective method of preventing turtle hatching confusion. Save Our Marine Turtles (SOS) is a recognized community-based organization created in 2000 with the purpose of conserving Tobago's marine turtles. Regular patrols assist confused hatching in finding their way to the sea and prevent poaching of these magnificent animals.

According to this paper [5] findings, adding colourful material to hotel seafront windows should lessen the confusion of loggerhead sea turtle hatchings. As a result, the successfully fledged hatching would have more opportunities to locate the sea. Reduced artificial lighting along ocean fronts will increase sea turtle populations by increasing the likelihood that fledgling turtles will discover the water. This could eventually result in the removal of Loggerhead sea turtles, as well as other sea turtle species, from the list of threatened species. With increasing numbers, Loggerhead sea turtles are better able to regulate and maintain the balance of seagrass beds and coral reefs, create natural habitats for a variety of plants and animals, and exchange energy within and between environments. Depending on the results of this evaluation, future inspections may call for similar light shielding at inns. This might resemble the foundations of houses or other seaside structures. Future studies could examine the impact that similar window tinting has on sea turtle settling as opposed to incubation. When female sea turtles approach the coast for acclimation, they are affected by simulated perpetual light pollution. Similar light shielding at lodgings is widely thought to be effective in alleviating ramifications for hatchings. As previously noted, another future study might concentrate on reducing the effects of light pollution from open-air dining establishments and meeting locations along seashores, particularly hotels on these ocean fronts. This should be doable using a window colouring method similar to the one employed in this study, or alternative routes might be investigated to find the best solution for that scenario.

This paper [6]implemented certain strategies that led us to compile relevant data which included observing light levels using the Sky Quality Meter (SQM), reviewing our stock along with making adjustments. This resulted in designing a leaflet, guide and public show. Our assessment of whether there was an improvement or degradation in light contamination relied on utilizing SQM light levels similar to what was done during the prior WEI crew's trip to Isla Verde. Our manufacturing process involved categorizing our products for Isla Verde and Patellas into various groups to guarantee consistent light fixtures. Providing JCA with the stock aimed at informing them about lights that failed to comply with requirements. The study enabled us to examine local inhabitants' understanding of the regulations, the consequences of light pollution on the environment, and what possible adjustments may be undertaken. The four most popular tools were used to plan adjustments once the stock was created. Among the installations were a square floodlight, a circular spotlight, a pickle container light, and a vault light. To make the changes, an aluminium sheet from a frying plate, plastic vases, and dark shower paint was employed. We developed several types of instructional effort once our stock was manufactured, the research reactions were examined, and the alterations were organized. It was determined that a trifold leaflet, a short booklet, and a public show were the best methods for contacting the local area and assisting with educating the general population about the effects of waterfront light contamination on ocean turtles, as well as the least difficult methods of reducing light contamination.

According to this paper [7] Several strategies have been put in place to reduce the impact of light pollution on sea turtles. Reduced light intensity along the shore is one of the most successful measures. This can be accomplished by utilizing low-pressure sodium vapour lamps, which generate a monochromatic light that sea turtles find less appealing. Furthermore, the use of motion sensors, timers, and shields can help to reduce the impact of light pollution. Another useful technique is to establish dark zones along the shore during the nesting season, where lights are forbidden or limited. Regulation, education, and outreach initiatives can be used to enforce these dark zones. Legislation has been implemented by the Fish and Wildlife Conservation Commission in Florida, mandating that proprietors of coastal properties must conceal their lights during the sea turtle breeding season. In addition, the implementation of public outreach and educational initiatives can effectively enhance knowledge dissemination regarding the impact of light pollution on sea turtles, and promote the adoption of optimal strategies to alleviate such impact. These efforts can be directed at a number of different targets, including coastal property owners, companies, and the general public.

According to the research paper [8], "Lights out" ordinances can increase sea turtle survival. Examples include the marine turtle preservation lighting code in Santa Rosa County, Florida, which mandates turtle-friendly lighting and the closing of blinds by nine o'clock at night. Other options to stop light pollution and encourage successful sea turtle nesting activities include placing tall objects or planting shrubs.

VII. Conclusion

Overall, light pollution has a detrimental effect on ocean turtle populations, altering their desire to nest, the survival of their hatching, and the sex ratios. The natural indications that ocean turtles rely on to survive and navigate are disrupted when artificial light is utilized poorly or unnecessarily, which

confuses their hatching and alters the sex ratios in their populations. We understandably want to act quickly to mitigate the consequences of light pollution on ocean turtles and their environment. This should be accomplished by implementing suitable lighting standards, such as using less dangerous golden or red lights, constructing barriers to divert light away from the ocean side, and minimizing artificial light during hatching and settlement seasons. Light pollution can also be combated through education and public awareness. Educating the general people on the effects of light pollution on sea turtles and other wildlife can lead to behavioural changes and increased support for conservation initiatives. Enabling reliable lighting habits, such as shutting off exterior lights when not in use, can also aid in the reduction of light pollution.

Although some progress has been made on the issue of light contamination, more needs to be done. Cooperation among government agencies, non-governmental organizations, and nearby networks is critical in developing systems that limit the effects of light pollution on ocean turtle populations. The widespread threat presented by light pollution to ocean turtle populations necessitates immediate action. We can help ocean turtles and other creatures impacted by light pollution by implementing sensible lighting practices, training and mindfulness efforts, and collaboration among partners.

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