The Hawksbill Sea Turtle: A Critically Endangered Species' Battle with Climate Change

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Introduction:

A sea turtle's existence is a battle for survival from the moment it hatches (Buis, 2019). Due to natural predators and other barriers, only one sea turtle out of every 1,000 eggs laid survives to adulthood (Buis, 2019). Those that do survive confront countless risks from humans (Buis, 2019). For instance, in some regions, they are hunted for their meat, eggs and shells (Buis, 2019). Their natural coastal habitats are altered and get developed progressively, while their beaches and seas are contaminated by harmful marine debris and oil spills (Buis, 2019).

Sea turtles are currently facing even larger existential dangers as a result of climate change (Buis, 2019). Because they spend their lives in both marine and terrestrial ecosystems, the effects of climate change are anticipated to be catastrophic to these endangered species (Sea Turtle Conservancy, 1996). Due to coastal erosion brought on by storms and rising sea levels, nests may be flooded or washed away (Buis, 2019). Similarly, ocean currents, the migratory routes used by sea turtles, are also changing as a result of warming climate (Buis, 2019). Consequently, sea turtles may be forced to adjust their movements, range, and nesting timing due to variations in ocean currents (Buis, 2019). Moreover, the temperature of the beach sand at which the eggs are incubated determines the sex of a sea turtle; higher temperatures result in greater proportion of females, while temperatures over a certain threshold increase mortality (Buis, 2019). This implies that a decline in the number of male sea turtles caused by our warming climate may be driving sea turtles into extinction (Buis, 2019).

What is a Hawksbill Turtle?

The hawksbill sea turtle is one of the smallest species of turtle (National Geographic, 2015). It is distinguished by a narrow, beak-like mouth and a stunningly patterned shell (Figure 1) (National Geographic, 2015). It inhabits the warm, tropical shoreline seas of the world's major oceans (Figure 2) (National Geographic, 2015). The hawksbill turtle is omnivorous (Meylan, 1988). Similar to a bird of prey, their narrow, pointed beak is a specialised feeding tool; it is ideal for penetrating hard-to-reach cracks and cervices on the reef to extract sponges and other invertebrates (Meylan, 1988). The primary source of food of the Hawksbills are coral reef sponges, making hawksbills the only species of sea turtles that can subsist primarily on sponges as their diets (Meylan, 1988). For most animals, sponges are toxic as they contain glass-like spines and other toxic chemicals (Meylan, 1988). However, hawksbills are immune to these toxic compounds and are able to neutralize the glass-like spines, making their competition relatively minimal (Meylan, 1988). This form of feeding benefits other marine species on the coral reefs. For example, hawksbills contribute to removing prey such as sponges from the surface of the reef, which enables reef fish to have better access to feed (Meylan, 1988). This feature of hawksbills makes them a key element of the ecosystem that contributes to the health of the coral reefs and other marine life (Meylan, 1988). They also feed on sea anemones, sea urchins, mollusks, and jellyfish, and are classified as opportunistic predators (Meylan, 1988).

Sea turtles are the surviving descendants of a species of reptiles that have roamed our oceans for the last 100 million years (Plant, 2022). Unfortunately, the hawksbill turtle is the most endangered species of turtle and ranks 4th among the top 10 most endangered species (Plant, 2022). Over the last 200 years, human activities have shifted the odds against the survival of these ancient mariners (Plant, 2022). Sea turtles are threatened by the loss and degradation of nesting and foraging habitats, bycatch in fishing gear, direct harvest of their eggs, ocean pollution, and most importantly, climate change (Plant, 2022). Due to warming temperatures, changes in beach morphology and higher sand temperatures are inevitable (Laloë et al., 2016). Both of these factors can be lethal to eggs or alter the ratio of male to female offspring produced (Laloë et al., 2016). The sex of hawksbills is determined after fertilization (Laloë et al., 2016). Whether a hatchling will be a male or female depends on the temperature of the developing eggs, which is called temperature-dependent sex determination (Laloë et al., 2016). As a result, rising temperatures have lately been highlighted as one of the biggest threats to the viability of sea turtle populations (Laloë et al., 2016).

The Impact of Rising Sand Temperatures on the Hawksbill Turtle Populations:

As previously mentioned, for species that display temperature-dependent sex determination, the risks of rising temperatures are particularly pronounced as they may result in anomalies in the sex ratios and local extinctions (Laloë et al., 2016). Like all other species of sea turtle, hawksbill turtle is one of the species whom sexual differentiation is influenced by the temperature of the sand where the eggs are incubated (Laloë et al., 2016). If the eggs incubate in higher temperatures, hatchlings will primarily be females, however, if the eggs incubate in cooler temperatures, primarily male hatchlings will be produced (Laloë et al., 2016). Meanwhile, the incubation period and constant incubation temperature that produces 50% of each sex is referred to as the pivotal duration or pivotal temperature, respectively (Laloë et al., 2016).

In a study, sand temperatures from a hawksbill nesting beach in Antigua were investigated to determine the effects of high sand temperatures on sex ratio of hawksbills (Glen and Mrosovsky, 2004). It was discovered that temperatures at 30 and 60 cm depths surpassed the pivotal temperature of 29.2 ^{o}C (Glen and Mrosovsky, 2004). Consequently, this nesting beach ended up producing highly female skewed sex ratios (Glen and Mrosovsky, 2004). Furthermore, this experiment was conducted during main nesting seasons in 1989, 1990, and 2003, in order to compare the sand temperatures in different years and subsequent sex ratios of hawksbills. It was discovered that the sand temperatures in 1989 and 1990 were considerably cooler during nesting seasons of hawksbills than the nesting season for 2003 (Glen and Mrosovsky, 2004). The difference in sand temperatures between 1989-1990 and 2003 was then reflected on the number of female hatchlings produced, which was higher in 2003 (Glen and Mrosovsky, 2004).

In addition, according to Godfrey et al. (1999), in an experiment conducted on Buck Island in the Caribbean, two hawksbill turtle nests that were in the shade (i.e., cooler temperatures) produced more male hatchlings than the two nests that were in full sun. Moreover, it was also discovered that there were far more female than male dead hatchlings remaining in the nests that were in full sun (Godfrey et al., 1999). Also, due to the overall sun exposure of this island as a result of decrease in shaded areas, during nesting seasons of hawksbills, the majority of the hatchlings from turtle nests in this area are expected to be female (Godfrey et al., 1999).

To summarize, on account of their temperature-dependent sex determination, sea turtles, especially those in their terrestrial reproductive phase, are extremely susceptible to temperature changes (Evans et al., 2022). The ratio of female to male sea turtles is expected to increase disproportionately due to predicted rises in global temperatures, potentially leading to loss of genetic diversity owing to diminished sperm competition, multiple paternity, as well as inter- and intra-sexual competition (Evans et al., 2022).

Conservation Strategies:

Unfortunately, due to human interference, the populations of these majestic and ancient marine species have been declining, posing an ever-growing threat of extinction (Laloë et al., 2016). This is why there is a widespread concern for the conservation of the critically endangered hawksbill sea turtle (Laloë et al., 2016). Extensive conservation efforts are devoted to the protection of sea turtle populations around the world, which have led to increases in the number of nests for a wide range of populations and species (Laloë et al., 2016). However, as climate change continues to pose a threat to these species' viability, assessment of climate change's effects has been deemed a top global research priority for future turtle conservation, and quantifying the impact of warming temperatures has been identified as a conservation priority (Laloë et al., 2016). Regarding the issue posed by increasing incubation temperatures, conservation strategies include artificial shading, watering, and relocating the eggs to deeper sand depths.

In a study that investigated the effects of shading with different materials (i.e., shaded with white cotton sheet, white sand, or palm leaves), all three treatments showed a linear, declining trend, demonstrating the efficacy of lowering sand temperatures (Figure 3) (Esteban et al., 2018). This finding was supported by another study conducted by Hill et al. (2015), where the sand temperature of sea turtle nests were significantly cooler when shaded with fence mesh. These two results demonstrate that artificial shading may strongly influence sea turtle incubation conditions while being simple, inexpensive, and low technology (Esteban et al., 2018).

Similarly, the effect of water treatment on nest temperatures was revealed in a study conducted by Hill et al. (2015). It was observed that the temperatures between the control (no water treatment) and all water treatments (low and high water treatments) varied significantly (Hill et al., 2015). The temperature of quadrants that received the highest amount of water decreased more than the temperature of quadrants that received lower amounts of water (Hill et al., 2015). Nevertheless, the temperatures of plots that received water were all significantly cooler than the control quadrants (Hill et al., 2015). However, temperatures in watered plots reverted to control values approximately within 10 days after the water treatment was stopped (Hill et al., 2015). This was because the temperature of the beach is driven by solar radiation, preventing it from having a long-lasting watering effect on the sand (Hill et al., 2015). Therefore, nests should be watered relatively frequently depending on the precipitation of the area, considering the incubation time of hawksbill eggs, which is around 60 days (Hill et al., 2015).

Lastly, the relative impacts of shading and watering were compared to different depths in sand (Hill et al., 2015). It was observed that at 75 cm, water content tended to be higher, which was most likely as a result of evaporation in the sand's top layer (Hill et al., 2015). Furthermore, this trend was supported by analyses of water content on the Playa Grande beach (Hill et al., 2015). It was revealed that measured water content was much greater at 75 cm than at 45 cm (Hill et al., 2015). Additionally, as depth increased, shading of the nests increased respectively, allowing cooler sand temperatures (Hill et al., 2015). Therefore, the effect of different depths is crucial to take into account when developing conservation strategies because of the considerable interactions that depth has with both water content and shade (Hill et al., 2015).

To sum up, these beautiful creatures are threatened by the destabilizing effects of climate change, and they need our help to protect them from going extinct. As shown in various studies, there are many conservation strategies that may be implemented to protect and recover this endangered species (Hill et al., 2015; Laloë et al., 2016; Esteban et al., 2018). In regard to the challenge they are facing due to changes in beach morphology and higher sand temperatures, artificial shading and watering of the nests, as well as relocating the eggs to deeper sand depths have all been shown to be effective at lowering the temperature of the sand where the eggs are incubated (Esteban et al., 2018; Hill et al., 2015). Consequently, the impacts of climate change, especially on the eggs and hatchlings can be mitigated, allowing for less skewed sex ratios and higher success rates of hatching.

Figures:

Figure 1. Hawksbill sea turtle swimming underwater. (Photo taken by U.S. Fish and Wildlife Service) (Source: NOAA Fisheries, 1997).

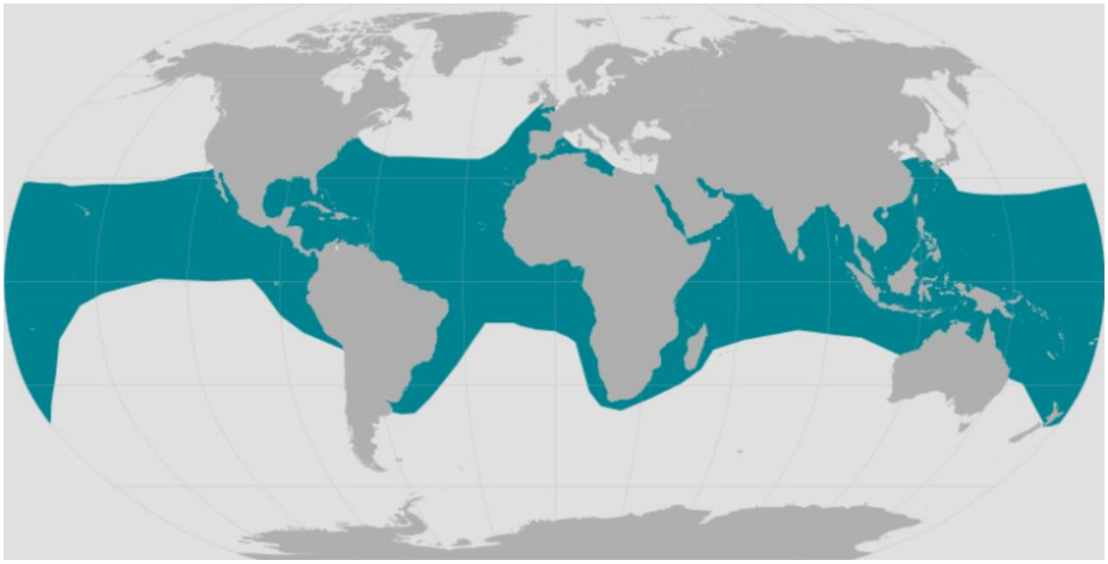

Figure 2. World map providing approximate representation of the hawksbill sea turtle's living habitats. (Source: NOAA Fisheries, 1997).

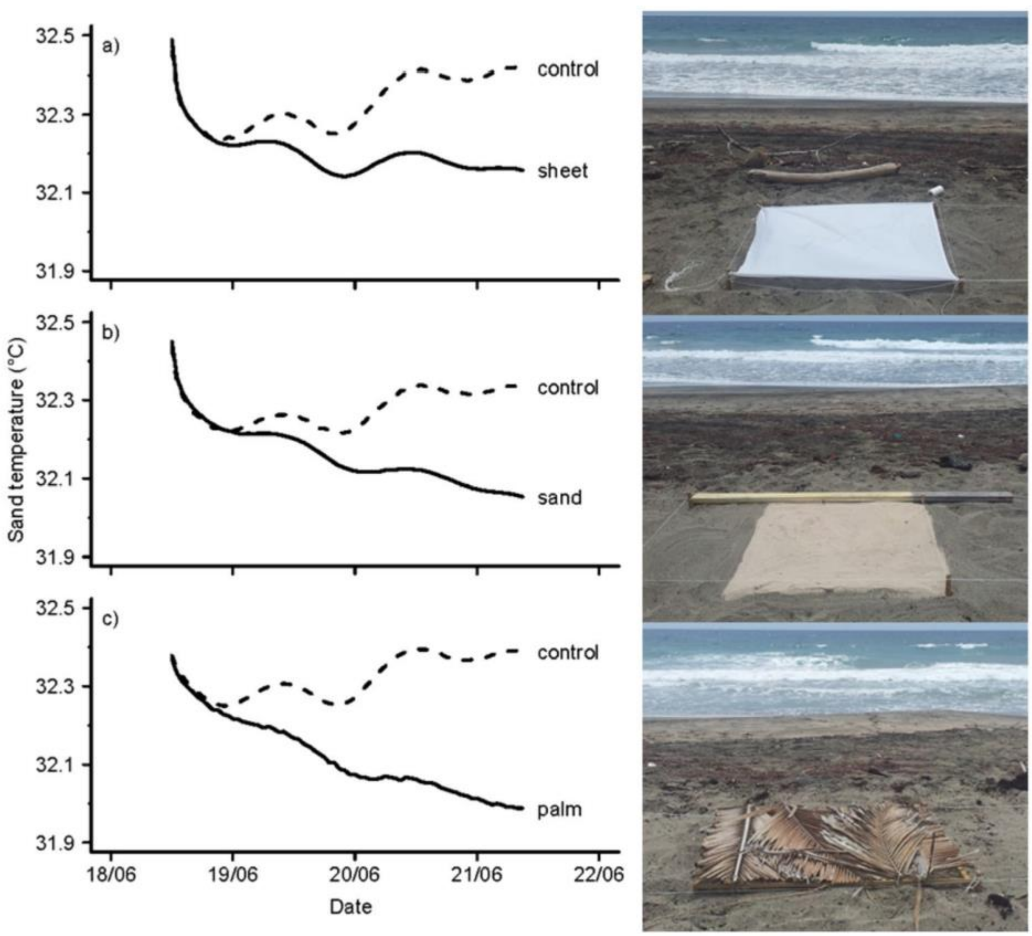

Figure 3. Shading strategies employed at mean hawksbill and green turtle nest at depth of 50 cm. (a) White cotton sheet (b) White sand (c) Palm leaves. (Esteban et al., 2018).

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