Reviewing the Status of Turtles in Kenyan Aquatic Ecosystems: Threats and Current Conservation Efforts

Erick O. OGELLO*, Jeniffer KINGA, Janet MWANZIA, Nicholas OUTA & Mavindu MUTHOKA

[1]Department of Animal & Fisheries Sciences, Maseno University, P.O. Box Private Bag, Maseno, Kenya

*Corresponding author: erick.ogello@gmail.com

ABSTRACT

Turtles are ancient repltiles with significant economic, ecological and social values to humanity. Due to the high demand for commercialized sea turtle products, turtles have been classified under 'Critically Endangered', 'Endangered' or 'Vulnerable' by the World Conservation Union. The long-term survival of turtles is contingent on the protection of nesting areas and the education of local communities on their conservation and importance. Pollution, loss of nesting grounds, bycatch in fishing, poaching, and climate change contribute to the decrease of turtles. If these causes are left unchecked, they may have devastating effects on the turtle population. Long-term monitoring is therefore essential for gaining a thorough understanding of turtle population dynamics and assessing the efficiency of conservation measures. We conducted a review of the most recent literature to guide future research, emphasizing the basic biology of turtles with a focus on the Kenyan situation. The review has revelaed that Kenya is home to a variety of turtles, including both marine and freshwater turtles. The green turtle (Chelonia mydas), hawksbill turtle (Eretmochelys imbricata), loggerhead turtle (Caretta caretta), Olive Ridley turtle (Lepidochelys olivacea), and leatherback turtle (Dermochelys coriacea) are some of the marine turtles found in Kenyan waters. The paper further discusses the importance of turtles, the risks they face, presents conservation measures as well as what can be done to raise their survival rates. This review proposes that government, non-governmental organizations and community must devote special attention to the development and execution of scientifically sound, conservation measures to reduce activities that place turtles under threat.

Keywords: Turtles, Endangered, Vulnerable, Conservation

INTRODUCTION

Turtles are aquatic creatures linked to dinosaurs that have been on the planet for almost 200 million years (Doherty et al., 2020; Rhodin et al., 2008). They survived the end-of-Cretaceous-period mass extinction when most dinosaurs died off (van der Zee et al., 2021). Kenya is home to a variety of turtles, including both marine and freshwater turtles. The green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*), Olive Ridley turtle (*Lepidochelys olivacea*), and leatherback turtle (*Dermochelys coriacea*) are some of the marine turtles found in Kenyan waters (Okemwa et al. 2004). The majority of these species are found foraging in mangrove swamps, sandy beaches, seagrass meadows, and coral reefs, which offer sea turtles a pristine environment (Okemwa et al. 2004). *C. mydas*, *E. imbricata*, and *L. olivacea* are among the species that have been known to nest at Lamu, Kenya. *D. coriacea* and *C. caretta* forage in Kenyan waters but do not lay their eggs there (Church and Palin, 2003).

The most prevalent animal foraging and breeding throughout Kenya's coastal waterways is the green turtle (Olendo et al. 2016). It features a teardrop carapace that comes in a variety of hues, including black, green, olive, yellow, and dark brown. They consume seagrass and algae and are herbivores (Jensen et al., 2020). The Hawksbill turtle is well-known for its stunning shell and peculiar pattern of overlapping shells that produce a serrated edge on the edges and are also coloured (Arantes et al., 2020). Loggerhead turtles have large heads and strong jaws, as well as larger shells with a heart-shaped carapace (Evans et al., 2019). Adults are carnivores who devour crabs, whelks, and conchs, but hatchlings are omnivores (Molter et al., 2021). Olive ridley sea turtles are one of the tiniest sea turtles with an olive-coloured heart-shaped carapace (Kitayama et al., 2021). The carapace of the leatherback turtle is made up of cartilage-like tissues and is strong and springy (Eckert et al. 1999). The Lamu seascape is said to be home to Kenya's most important turtle nesting beaches, with 34 sea turtle nesting beaches spread over five areas (Church and Palin, 2003).

The age of the turtle, as well as physicochemical water quality characteristics such as upwelling, water depth, and temperature, influence movements and time spent in feeding grounds by turtles (Jensen et al. 2016). Throughout their lives, sea turtles, inhabit a variety of environments, including marine, coastal, neritic, and nesting beaches, as well as crossing many ocean basins and Exclusive Economic Zones (EEZs) for food and reproduction (Jensen et al. 2016). However, their natal

homing behaviour has altered their foraging and nesting preferences (Lohmann et al. 2013). Due to this complex life cycle, cooperative and international approaches to conservation that interconnects humans, sea turtles and their habitats while applying the best scientific knowledge are required.

Turtle species are also listed as 'Critically Endangered, 'Endangered' or 'Vulnerable' due to unsustainable human activities such as fishing, pollution, and coastal developments (Lyson et al. 2011). The coastal ecosystems i.e., seagrasses, mangroves, coral reefs, and sand bars in the Kenyan waters have proved to be excellent places for the thriving of turtle populations. However, most of these ecosystems are threatened by pollution, climate change, population growth, and mismanagement of resources (Eckert et al. 1999). To curb some of these threats posed to turtles, several actions have been taken to make sustainable changes to the coastal ecosystems. Some of the efforts made by the native community include strategies to prevent the use of unsustainable and illegal fishing gears, locally managed cleanups and waste collections, community-managed marine protected areas, and community-led mangrove replanting and management (Eckert et al. 1999). However, most of these initiatives have not been able to sustain themselves due to a lack of finances. This has led to detrimental effects by human activities on the Kenyan beaches mostly used by turtles as nesting grounds thus threatening their existence (Obare et al. 2019). The problems faced by turtles is acerbated by a scarcity of knowledge on the benefits of turtles. Understanding their significance can aid conservation efforts and mitigate some of the anthropogenic dangers that turtles face. To ensure the continuity of turtle generations, appropriate and standard conservation measures must be undertaken by both local communities, government and non-governmental organizations. Proper management planning for the conservation of turtles cannot occur without the support of scientific research. The present study reviews the literature on the status of turtle species in Kenya, their importance, threats that have rendered them endangered, and the present state of sea turtle conservation initiatives. The authors suggest some of the conservation actions that can be taken to reduce the loss of turtle species diversity and abundance as well as improve the conditions of their nesting and foraging grounds.

Status of turtles in Kenya

To date only one freshwater turtle, *Pelusios broadleyi*, also known as the Turkana mud turtle has been reported in Kenya. It belongs to the Pelusios genus and species *P. broadleyi*. Lake Turkana

is its natural habitat (Leakey et al., 2011). It is the smallest member of its genus and is commonly kept as a pet due to its ease of maintenance (Ducrocq et al., 2011). There is still a lack of scientific knowledge about their biology, ecology, and the risks they confront.

Marine turtles differ from freshwater turtles in that their front limbs are flippers, their carapaces are large, their shells are hard, and they rarely leave the ocean except to lay eggs. The freshwater turtles' front limbs are toes, their carapaces are smaller, and their shells are soft and pliable (Shimada et al., 2020). They can leave their homes to sunbathe on rocks or logs in the warm sun. Only the oceans and seas are home to marine turtles. Their heads and necks may be extended for half the length of their plastron, have eleven scutes, and have more than fifteen stripes on the neck, all of which can be used to estimate their ages. Freshwater turtles' dwell in ponds and lakes, and their heads and necks are longer than their plastron, with twelve scutes and fewer than fifteen stripes on the neck.

Ecology of turtles

Marine Ecosystems

. Marine ecosystems such as oceans and seas, and their ambient ecosystems i.e., salt marshes, mangrove wetlands, estuaries, are perfect habitats for marine turtles (Senko et al., 2020). . These habitats are more vulnerable to pollution than freshwater environments (Dierkes et al., 2019).. Except for ridley and flatback turtles, which have a worldwide range, hawksbills are generally found in tropical areas, whereas leatherbacks graze in cooler, often polar waters (Eckert et al. 1999). Turtles that dwell in marine habitats have highly developed morphologies and are suited to high salt levels (Eckert et al. 1999). Flippers are used by all sea turtles to assist them to move about.

Sea turtles come out to the beach to breathe for a few minutes or seconds before holding their breath for over two hours (Jeantet et al., 2020). Algae and seagrass, as well as jellyfish and, for certain turtles, tiny crustaceans, are the most plentiful foods in the maritime ecosystem. Adult turtles spend most of their time foraging ground, which is apart from the nesting beach (Shimada et al., 2020). Adult turtle foraging sites can be permanent, such as seagrass meadows, or temporary, such as regions in the ocean containing seasonably predictable benthic invertebrates or jellyfish blooms (Eckert et al. 1999). The larger shoulder girdle of sea turtles has a noticeably elongated coracoid, which serves as a point of attachment for the well-developed pectoral muscles necessary

for swimming. They all have notably enlarged and modified lacrimal or tear glands that drain excess salts from bodily fluids. Sea turtle shells have less bone and are streamlined to varying degrees to increase hydrodynamic efficiency (Eckert et al. 1999). Marine turtles have a lower capacity to retract their heads than other cryptodires, but they have a thick, virtually full skull roofing that provides extra head protection (Gaffney & Meylan, 1988).

Freshwater ecosystems

These ecosystems have very low salt levels and are generally less stressful to inhabit. Most freshwater turtles also tend to be euryhaline and tolerate a wide range of salinity (Agha et al., 2018). Such ecosystems include. Lakes, rivers, streams, ponds, marshes, and bogs are among them. The turtles in this area have toes so that they may grip onto logs and rocks when they are not in the water (Ducrocq et al., 2011). These turtles have strong connective tissues that allow them to swim more efficiently. The most common defensive strategy is to retreat within their shell. Because freshwater turtles go on land numerous times, invertebrates such as snails, insects, and crayfish, as well as aquatic and terrestrial plants, are the most plentiful diet (Bannister et al., 2021).

Biology of turtles

Understanding turtle reproduction and nest biology are critical for turtle stock recovery and management. Lack of understanding of turtle biology can lead to well-intentioned but ineffective conservation initiatives that harm turtles (Cooney et al., 2017). Many behavioural features, particularly those related to reproduction, are shared throughout turtle species. As a result, all sea turtle species have relatively similar approaches for studying and maintaining them. Female turtles nest many times during the reproductive season, and the majority of them do not nest in the same year (Eckert et al. 1999). In terms of nest size and construction details, nesting method, nesting environment choice, average clutch size, and size at first reproduction, there are species-specific variances (Eckert et al. 1999).

Mating of turtles

Turtles mate mostly during spring (Cassola et al., 2020). In an attempt to seduce a female turtle, a male turtle approaches her. It chews its neck, shell, and even flips it over with its teeth. This might last up to 45 minutes until the female is ready. When the female is ready, she descends to the bottom and waits to be mounted, while the male follows and climbs on her back (Lasala et al.,

2020). Male and female sea turtles both have cloacas near the base of their tails, which keeps the male turtle's penis . The male will then reach the female shell's rear end with his tail and inseminate there. As competition from rival males is ready to begin, the male puts his claws into the female's shell and holds on for dear life (Doherty et al., 2020). Mating can continue for up to 24 hours. After then, the female can mate with different malesuntil all of her eggs are fully fertilized.. They excavate a u-hole-like vessel two-feet deep with their flippers and lay their first batch of eggs (Hays et al., 2021). Turtles can lay many clutches of eggs. Multiple partners can be found in a single clutch of eggs. The female turtle spends more time on land than in the water during the penultimate week of gestation, ready to lay the eggs.

The life cycle of a turtle

Female turtles dig nests that range in size from 5 to 7 inches in diameter, depending on the mother turtle. After the female has set her eggs in the sand, which occurs mostly at night, nocturnal nesting is favourable since there is less risk of burning in the sun and there are fewer predators on the beach at night (seaturtlecamp.com., 2016). Different conservation parastatals in other nations translocate turtle nests dug below the high-water line of the sea coast to duplicates of natural nests above the high-water mark. For example, the Kenya Wildlife Service (KWS) has patrol teams who give protection to these turtles while they are hatching at night and guarantee or secure the safe return of the mother turtle to the sea once she has laid eggs.

Turtle eggs hatch about 3-4 months after fertilization, depending on the turtle species (Putman et al., 2020). The gender of the hatchlings is influenced by the temperature where the eggs were deposited. Females outnumber males when the temperature rises. Male hatchlings are produced in nests with temperatures below 81.86 degrees Fahrenheit, whereas female hatchlings are produced in nests with temperatures above 81.8 degrees Fahrenheit (NOAA., 2021). The hatchlings in the eggs mature and hatch at night, marking the end of the gestation period since they were deposited.

A baby uncuts its body and shell after hatching, with a yolk sac protruding from the plastron (underside of the shell), much like a mammalian placenta. In the early days of the turtle's existence, the yolk sac is absorbed into the infant body, giving sustenance (Cassola et al., 2020). After leaving the nesting site, the juvenile stage enters a pelagic phase that lasts many years. Hatchlings follow the sound of the wave, the downward slope of the beach, and the reflection of the moon and stars in the water, where their fight for survival begins (Hays et al., 2020). Only about one in 1,000 turtles survive to adulthood as hatchlings, as they die of dehydration if they don't make it to the ocean quickly enough, or face predators such as birds and crabs (Rhodin et al., 2008). The life cyle is summarized in Fgure 1 below.

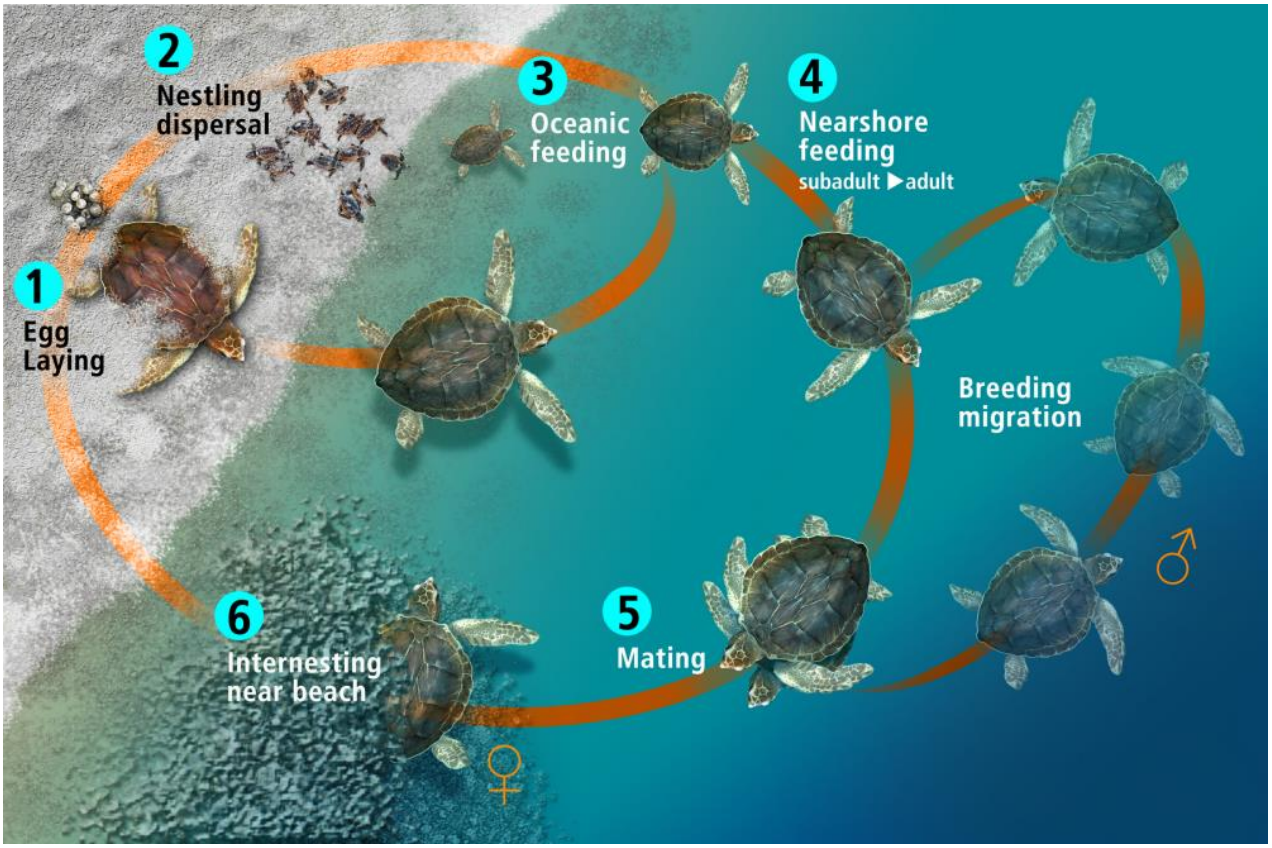

Figure 1: Life cycle of a sea turtle. (https://www.coroflot.com/katesweeney/sea-turtle-life-cycle)

They are frequently seen at sea at frontal limits near large currents, generally coupled with drift or weed lines. The pelagic phase, which varies in length depending on the species, is missing in flatback turtles but present in others (Walker and Parmenter, 1990). Green turtles, hawksbill

turtles, and Kemp's ridleys, for example, continue in the pelagic environment until their carapace length is between 20 and 30 cm (Eckert et al. 1999). Some turtle have been collected repeatedly in the same region over several years, showing residence in these developing settings (Eckert et al. 1999). The mature stage of the turtle's development and survival period, and the events of the turtle's life at this stage cannot be traced back . Wild turtles are said to have a sluggish development rate, ranging from 15 to 50 years or more, depending on the species and geographic region (Bjorndal and Zug, 1995).

When the turtles reach adulthood, they return to the identical area where they were born to mate and lay eggs, ensuring the turtle race's survival. Mating occurs in the migratory corridor, at courtship or breeding stations, and in the area of the nesting beach, and the reproductive season can last up to several months (Eckert et al. 1999). Turtles can detect the invisible lines of the magnetic field that affect their return to their original habitat, functioning as an internal GPS to aid their navigation (Arnold., 2015). Their way of life repeats itself after mating.

Importance of turtles

Economic importance

Turtles are mostly hunted for commercial purposes and their flesh, eggs, oil, skin, and shells (carapaces) (Miller et al., 2019). The eggs are said to be aphrodisiac and good for the skin. Turtle flesh is high in protein and other micronutrients including potassium, zinc, vitamin b12, thiamine, iron, selenium, and riboflavin, all of which aid in the formation and functioning of bones, muscles, and the brain (Tisdell & Wilson, 2002). Because it has extremely little fat and nearly no carbs, its flesh is recommended. Turtle eggs are high in amino acids and organic substances, which aid in the body's protein synthesis. It also contains a lot of omega 3 fatty acids (Miller et al., 2019).

Turtle oil has anti-inflammatory effects hence used to treat cardiovascular conditions. It contains a chemical compound that's utilized in sunscreens and burn treatments. It's also included in cosmetics and beauty products that help to minimize wrinkles and improve the healing abilities of sensitive skin (Yang et al., 2021). Belts and handbags are made from turtle skin. Jewellery, combs, brush handles, and adorned boxes are all made from turtle shells with exquisite carapaces or shells. As pets, freshwater turtles, usually terrapins, are purchased and kept by some pet lovers (Hossain & Heo, 2021).

Turtle tourism generates additional revenue and job opportunities for the local community, bolstering local and regional support for conservation initiatives. Turtle tourism- the visit by people for the primary reason of seeing and (maybe studying turltes) also educates visitors about sea turtles and raises awareness of the issues and hazards they face. It also instructs visitors on how they may aid turtle conservation (Tisdell & Wilson, 2002). Ecotourism that includes wildlife watching – including turtles is usually labour-intensive, and it frequently relies on local volunteers to make it financially feasible (Cooney et al., 2017). Volunteers may assist with crowd management, admittance costs, scientific data collection on turtles, running a small souvenir store, and organizing watching parties. Local support for turtle protection is increased as a result of this engagement, while economic consequences that may potentially cripple the tourist industry are avoided (Leduc & Hussey, 2019). A classical example is the Watamu Turtle Watch at the Kenyan Coast which employs volunteers to assist in such activities.

2.4.2 Ecological importance

Turtles, both marine and freshwater, play a crucial role in aquatic habitat protection. Freshwater turtles operate as scavengers, which helps to maintain the health of both the land and aquatic ecosystems in which they live (Agha et al., 2018). Loggerheads eat jellyfish and crustaceans, which helps to keep their numbers in check. They make it easier for nutrients to go from water to land. When turtles graze on the seafloor, they crack the crustacean shells and aid in their disintegration, allowing for quicker decomposition and the release of nutrients (Valdivia et al., 2019). Hawksbill turtles keep coral reefs healthy by feeding on sponges that would otherwise overtake the coral, cover it up, and destroy it if left unchecked. As a result, hawkbill turtles assist reefs in resisting growing challenges such as climate change, algae overgrowth, and pollution.

During the nesting season, marine turtles come to coastal areas to lay eggs, which provide important nutrients to coastal dune ecosystems. Many predators feed on the hatchlings and eggs, while the empty shells give nutrients that invertebrates and bacteria may recycle (Shimada et al., 2020). Plants, in turn, use these nutrients, which help to stabilize the dune structure. As a result, turtles carry nutrients from far-flung productive feeding areas to nutrient-depleted coastal habitats, ensuring their stability.

2.4.3 Cultural importance

Turtles are said to be spirit creatures that represent knowledge, longevity, calm, and constancy (Hossain & Heo, 2021). They are immune to change in the sense that wherever they swim, they are constantly connected to the magnetic field of the place where they hatched, and hence will always return to mate where they were born (Evans et al., 2019). In Kenya, sea turtle products are said to have anti-evil spirit characteristics as well as medicinal ones, which is why turtles are harvested or poached for protection. This notion has had a significant influence on the loss of turtle populations in the Malindi and Lamu Archipelagos, as well as the growing commerce in poached sea turtles and their eggs (Nzuki, 2005).

In other regions of the world, for example, the Wayuu people of Colombia and Venezuela, who are known as sea shepherds, regard turtles as sea cattle. The water is the Wayuu's background, while coral reefs are flowers in their gardens. As a result, they have historically protected turtles as well as entire marine ecosystems. Sea turtles are used by the tribe as a preventative medication against bad spirits that cause disease and death in the community, therefore conserving and safeguarding the turtles (WWF 2005). Marine turtle dreams are interpreted as messages from Malewa (God) and the ancestors. The Wayuu people believed that sea turtles followed the deceased to eternity and that sharing turtle flesh at funerals lessens pain and suffering among mourners. Wayuu young boys had to harvest turtles in front of the community to display maturity, while young ladies had to shower with moon water dripping from the sea when they reached adulthood. Turtle carapace is used by the younger generation to get advantages like fertility, longevity, and tranquillity while also helping to save turtles and their environments so that their culture can continue (SWOT REPORT 13, 2018).

Turtles are considered an emblem of life by the aboriginal tribes of Australia since they supplied sustenance for the community. It refers to diverse spiritual ideas and hence deserves significant respect, as well as the obligation to safeguard and conserve the environment (Robinson, 2018). Due to the dread of being captured, researchers have had a tough time finding useful data on sea turtles and their cultural significance from the millennia's indigenous residents.

Threats faced by turtles

Turtles face a lot of threats especially from anthropogenic activities in and around their habitats. The greatest of these threats is related to fishing activities. Entanglement in long lines and gill net operations have resulted in turtle deaths (Bourjea et al. 2008). Due to overfishing and long-term damage, the inshore fisheries production along the Kenyan coast has drastically decreased (McClanahan, 1997). The entire catch is exceedingly low, resulting in poor revenues and a low standard of living for artisanal fishermen. Because of their great nutritional, economic, and cultural worth, fishermen want sea turtle harvests to enhance their catches (Wamukoya et al. 1997). Leatherback turtles are poached for their body oil, which is utilized in medicinal and industrial applications. In an illicit local market, a litre of sea turtle oil may be purchased for USD 40 (Limpus and Miller, 1993). Olive ridley turtles are killed for their leather, whereas hawksbill turtles are sought for their gorgeous shells, which are used to make high-end decorative and jewellery items (Tisdell & Wilson, 2002). The illicit and legal slaughter of sea turtles for meat and egg poaching is also a serious issue jeopardizing the ancient marine reptiles' existence. Many tribal groups, as well as coastal locations including at the Kenyan coast, gather turtle eggs for food. They are sold for their important source of revenue, putting the species' long-term existence in jeopardy (Tisdell & Wilson, 2002).

Turtle reductions are largely due to prawn trawling. Only a few prawn trawlers are licensed, even though the number of prawn trawlers has increased dramatically throughout the Kenyan coast. Within five nautical miles of the shore, prawn trawling is illegal; nonetheless, this law is frequently violated. Scientists have recently expressed worry about the high rate of turtle bycatch from trawlers. According to Mueni and Mwangi (2002), at least three turtles are collected in trawl nets every day, while the quantity varies depending on the season.

Turtles face also a significant danger of extinction due to manmade stressors such as direct hunting for eggs, shells, and meat, as well as a variety of natural concerns (Olendo et al. 2016). Olive ridley, green turtle, and loggerhead turtles are endangered, while hawksbill and leatherback turtles are severely endangered, according to the World Conservation Union Red List (IUCN, 2015). Turtles are highly migratory reptiles that travel between breeding and feeding places, spending the majority of their time at sea and among coral reefs (Limpus, 1991), rendering them exposed to a variety of threats, including motorized boat accidents and predation by bigger fish (Limpus and

Reimer, 1990). Natural predators such as land reptiles, marine birds, particularly skuas, and huge gulls may prey on the turtles (Tisdell & Wilson, 2002).

Due to pollution, the turtle population in Kenya is declining (Wamukota & Okemwa, 2009). Pollution has been claimed to pose a danger to the 200-kilometre coastline along the coast (UNEP 1998). Many hotels have been built for the tourism business, resulting in significant changes to the natural shoreline. Beaches have been severely harmed as a result of the construction of barriers (Mwanje, 1997). The dumping of oil waste and raw sewage into water sources contaminates the water and destroys the turtles' food plants. Strange pathogens are introduced during pollution, producing fibro papillomatosis (McLellan et al. 2012). Toxins are discharged into the environment via oil spills, fertilizer runoff, and chemicals generated by human interactions. As chemicals are broken down further, their destruction rates rise. Turtles breathe harmful vapours from oil spills when they rise to the surface to breathe, which are unpleasant and cause long-term problems. Turtles are more likely to become infected with Salmonella bacteria as a result of pollution.

Turtles' ecological processes have been reported to be threatened by climate change (Patricio et al. 2019). Each decade since the 1980s has been warmer than the previous one on record. Since 2005, 90 % warmest years have happened. Arctic temperatures are projected to be the warmest in the next 2,000 years, and atmospheric carbon dioxide is presently at 414 parts per million, the highest level in more than 100,000 years (Patricio et al. 2021). When the ozone layer weakens, direct solar rays can flow through to the earth's surface, causing global warming. Global warming is causing rapid climate change. Droughts and floods are examples of climate change in action, but only in extreme cases. Hatchling sex is governed by incubation temperature, and when temperatures rise too high, the normal sex ratio of turtles shifts, favouring females in a warm climate (Chatting et al. 2021). A turtle clutch will develop a male: female sex ratio of 1:1 at the crucial temperature of around 29 °C, which is the incubation temperature (Godley et al. 2002). According to Bentley et al. (2020), the crucial temperature may also differ significantly between populations and species.

Female bias in primary sex ratios has been documented in recent research for all marine turtle species in the area where they exist (Tanner et al. 2019). According to studies, the male generation may halt soon as a result of future climate change scenarios (Witt et al. 2010; Monsinjon et al. 2019). High temperatures cause coral bleaching, which affects the turtle's environment, with the hawksbill turtle being the most affected. When the temperature rises too much, the water level

drops, causing turtles to migrate. When there is a lot of rain, floods occur which may affect turtle populations since cooler temperatures accompanying floods, may alter the normal sex ratio in favour of males. Floods damage and destroy nesting beaches, and strong storms disrupt nesting habitats. As the polar ice caps melt, the seas level rises, washing nesting beaches away.

Turtles have been robbed of ideal breeding habitats due to the loss of beaches for coastal development to boost tourism. The majority of hotels in the coastal region are built along the ocean's edge, and turtle nests may be found on those sandy beaches. Due to lack of warmth, large and towering structures might cause turtle eggs to fail to incubate effectively (Tisdell & Wilson, 2002). Tourists strolling about may end up ruining the nests and eggs, resulting in no hatchlings. Lights from tourist automobiles and resorts near turtle rookeries are believed to confuse newly born turtles, causing them to migrate inland instead of heading to the sea when they emerge, exposing them to accidents and increased predation. The harvesting of Sargassum seaweed, which supplies turtle hatchlings with crucial food and shelter, is a severe danger to their existence and survival. Sargassum seaweed is mostly harvested by coastal communities as a low-cost animal feed component (Musick & Limpus, 1997).

Plastics are a major issue since they are non-biodegradable (i.e., they do not disintegrate). Tourists bring a lot of waste with them, including plastics, which end up in the water. When plastics are left in water, turtles may mistake them for jellyfish and consume them, hence getting choked, or suffocated as a result (Clause et al., 2021). They can't be digested when consumed, creating problems and intestinal obstruction. Sharp plastics rip internal organs, making it difficult for the turtle to consume, causing its growth to be halted or stunted (Limpus and Reimer, 1990). When turtles become entangled in plastic, they might drown. Chemical poisons in plastics raise the risk of diseases and lower the possibilities of reproduction.

During the entire turtle life cycle i.e., from the time the eggs are deposited until they reach adulthood, turtles are subject to a variety of human and natural risks. Man-made problems are becoming more prevalent by the day, thus regulations to preserve turtles should be enacted and enforced.

4.0 Existing conservation efforts in Kenya

Because of their larger range of mobility, turtle conservation and protection appear to be more challenging than for terrestrial animals. Their intricate and secretive lifestyle, in which they spend

most of their time at sea, make it more difficult to research them and design new conservation and protection techniques.

Certain conservation strategies, such as the treatment of industrial waste before disposal in coastal ecosystems, have been used in Kenya to fight the decline in turtle numbers. The Indian Ocean in Kenya, for example, has proven effective in controlling pollution and the introduction of harmful and invasive pathogens such as *fibropapillomas spp,* which cause fibro papillomatosis (McLellan et al. 2012), a disease that affects sea turtles and causes tumours that affect swimming, vision, feeding, and potential escape from predators, putting turtles and their health at risk.

Monitoring programs like the aquatic patrol team in Malindi and Watamu MPAs have assisted turtle nests from being damaged by high tides by relocating turtles to safe regions above the high-water line. The number of turtle nests tagged, the number of eggs in each nest, the date the eggs were laid, the estimated date of hatching, and the geographical positioning of the nest in terms of longitudes and latitudes are all recorded by Marine Parks and Reserves along the Kenyan coast. After hatching, how many hatchlings survive to the sea in good health is also recorded. Since turtles nearing their ocean nests are safeguarded and supervised, this has resulted in a rise in population.

The wildlife (conservation and management) Act, Chapter 376 of the Kenyan laws, part 2-Administration section 3A(f), empowers the Kenya Wildlife Service (KWS) to sustain wildlife to meet conservation and management goals, giving it the authority and mandate to arrest and prosecute anyone caught poaching or trading sea turtles and their products, effectively harvesting these magical creatures. Turtle conservation education and extension services are provided by KWS, KESCOM, and other organizations, such as local Ocean Conservation in Kenya, to raise public awareness and support for wildlife policies, thereby educating members of the community about the importance of conserving and protecting turtles. Watamu Turtle Watch, a local ocean conservation effort, urges people to contribute to the protection of sea turtles.

KWS also arranges beach clean-ups by young scouts in Kenya to minimize marine waste by picking up plastics discarded on the sand along the beach coastlines and disposing of them in the proper locations to avoid them becoming entangled and being eaten by turtles. Due to the growth of coastal tourism, KWS assures that visitors or tourists visiting the MPAs are plastic-free to avoid plastic being discarded on the beaches and becoming harmful waste on the sand. Kenyan fishermen

have been employing turtle excluder devices (TED) to provide an effective mechanism for excluding marine turtles without compromising target prawn and fish harvests (Kimani & Wambiiji, 2019). Turtles laying eggs at night and hatchlings hatching and securely reaching the sea have been supported by nesting beach programs, which protect turtles laying eggs at night and hatchlings hatching and safely reaching the sea without predation threats or risk.

The Wildlife Act (Cp 376) and the Fisheries Industry Act have been passed by the Kenyan government to conserve sea turtles (Cap 378). Hunting, trafficking, extracting, keeping, and transferring turtles and their products, whether living or dead, is prohibited under the law (Okemwo et al. 2004). Except for those that fall under Marine Protected Areas (MPAs), there are currently no rules preserving important nesting and foraging turtle behaviours. As a result, sea turtle poaching continues unabated, exacerbated by weak enforcement due to a lack of staff and infrastructure (Okemwo et al. 2004).

Kenya Sea Turtle Conservation Committee (KESCOM) was established in 1993 under the auspices of the Coastal Development Authority, Kenya Wildlife Services (KWS), Wildlife Clubs of Kenya, Fisheries Department (F.D), National Museums of Kenya, and Kenya Marine and Fisheries Research Institute to address the plight of sea turtles (KMFRI). KESCOM is an integrated national strategy for sea turtle conservation that encourages community engagement in activities including monitoring and research, lobbying, and public awareness. KESCOM has successfully pushed for all trawlers operating in Kenyan seas to be required to use Turtle Excluder Devices (TEDs) (Wamukoya et al. 1996). KESCO is fully reliant on the contributions of its members, interested people, and governmental agencies. According to research by Okemwa et al. (2004), KESCOM has nine community-based turtle conservation groups (TCGs) that help turtles at important nesting sites along the coast. All reported nests are dug, and the number of eggs each clutch is tallied by conservation organizations patrolling nesting beaches on foot, primarily at night (Okemwa et al. 2004).

The Lamu Marine Conservation Trust (LAMCOT) was founded in 1992 in response to unsustainable turtle and egg hunting in Northern Kenya's Lamu archipelago. LAMCOT has concentrated on turtles while also strengthening its ties with the local population to promote conservation and regional development. Nest protection, an incentive to fishermen for bringing in live turtles trapped in their nets, and beach patrols are among LAMCOT's current turtle

preservation measures. LAMCOT has also installed permanent buoys in sensitive reef areas so that snorkelling groups may tie up their boats without destroying the coral by dumping anchors. Every week, LAMCOT visits a local school to educate students about turtles and environmental conservation (NEMA, 2011).

Conclusions and recommendations

Turtles are necessary for the survival of humanity and the blue economy; thus, there is a need to conserve and safeguard them for the sake of the future. Currently, just a few sea turtle populations cover their full historical range. For a little more than a century, some of the world's biggest breeding assemblages of sea turtles have gone extinct. Although Kenya's lack of efficient legal enforcement to preserve sea turtles adds to the difficulty of providing proper protection, the country's general poverty is a major impediment to conservation efforts. Due to existing conservation initiatives, which have improved nesting density over time and reduced trends in sea turtle nest predation and strandings, the Kenyan coast has lately shown turtle population stability. However, their lives are put in jeopardy due to unavoidable situations such as migration.

Despite the present stability of the turtle population along the Kenyan coast, this assessment emphasizes the need for greater mitigation measures against the risks that turtles face, such as creating a sustainable economic activity such as turtle-based tourism, to support their protection. Surveillance and public awareness activities must also be escalated as a critical component of tackling most man-made activities, such as coastal development and fishing. Government and non-governmental organizations must devote special attention to the development and execution of scientifically sound, strict conservation programs. This may be accomplished by involving stakeholders, recruiting appropriate people and financial resources, and obtaining data that can be utilized to prepare for the measures and conservation efforts to be undertaken. More research is needed to accurately estimate the number of turtle populations, as well as data on whether populations are stable, declining, or rising. The intensive study should also be done on habitats which include nesting and foraging grounds.

REFERENCES

Agha, M., Ennen, J. R., Bower, D. S., Nowakowski, A. J., Sweat, S. C., & Todd, B. D. (2018). Salinity tolerances and use of saline environments by freshwater turtles: implications of sea level rise. Biological Reviews, 93(3), 1634–1648.

Arantes, L. S., Vargas, S. M., & Santos, F. R. (2020). Global phylogeography of the critically endangered hawksbill turtle (Eretmochelys imbricata). Genetics and Molecular Biology, 43(2), 1–12.

Bannister, C. C., Thomson, A. J. C., & Cuculescu-Santana, M. (2021). Can colored object enrichment reduce the escape behavior of captive freshwater turtles? Zoo Biology, 40(2), 160–168.

Bentley, B. P, Stubbs, J. L., Whiting, S. D., Mitchell, N. J (2020). Variation in thermal traits describing sex determination and development in Western Australian Sea turtle populations. Funct Ecol 34: 2302−2314.

Bjorndal, K. A. (1997). Foraging ecology and nutrition of sea turtles. In: Lutz PL, Musick JA (eds) The biology of sea turtles. CRC Press, Boca Raton, Florida, pp 199-232.

Bjorndal, K. A. and G. Zug. 1995. Growth and age of sea turtles, p.599-600. In: K. A. Bjorndal (Editor), Biology and Conservation of Sea Turtles, Revised Edition. Smithsonian Institution Press, Washington, D.C. 619 pp.

Bourjea, J., Nel, R., Jiddawi, N. S., Koonjul, M. S, & Bianchi, G. (2008). Sea turtle bycatch in the West Indian Ocean: Review, recommendations, and research priorities. Western Indian Ocean Journal of Marine Science 7: 137-150.

Cassola, F. M., Henaut, Y., Cedeño-Vázquez, J. R., Cruz, F. R. M. D. la, & Morales-Vela, B. (2020). Temperament and sexual behaviour in the Furrowed Wood Turtle Rhinoclemmys areolata. PLoS ONE, 15. e0244561.

Chatting, M., Hamza, S., Al-Khayat, J., Smyth, D., Husrevoglu, S., & Marshall, C. D. (2021). Feminization of hawksbill turtle hatchlings in the twenty-first century at an important regional nesting aggregation. Endang Species Res Vol. 44:149-158.

Church, J., & Palin, O. (2003) The sea turtle conservation ini¬tiative in the Kiunga Marine National Reserve, Lamu, Kenya from February 1997 to June 2003. Report for WWF East African Regional Programme Office, pp 107.

Clause, A. G., Celestian, A. J., & Pauly, G. B. (2021). Plastic ingestion by freshwater turtles: a review and call to action. Scientific Reports, 11(1), 56-72.

Cooney, R., Roe, D., Dublin, H., Phelps, J., Wilkie, D., Keane, A., Travers, H., Skinner, D., Challender, D. W. S., Allan, J. R., & Biggs, D. (2017). From Poachers to Protectors:

Engaging Local Communities in Solutions to Illegal Wildlife Trade. Conservation Letters, 10(3), 367–374.

Dierkes, G., Lauschke, T., Becher, S., Schumacher, H., Földi, C., & Ternes, T. (2019). Quantification of microplastics in environmental samples via pressurized liquid extraction and pyrolysis-gas chromatography. Analytical and Bioanalytical Chemistry, 411(26), 6959–6968.

Doherty, P. D., Broderick, A. C., Godley, B. J., Hart, K. A., Phillips, Q., Sanghera, A., Stringell, T. B., Walker, J. T., & Richardson, P. B. (2020). Spatial Ecology of Sub-Adult Green Turtles in Coastal Waters of the Turks and Caicos Islands: Implications for Conservation Management. Frontiers in Marine Science, 7, 1-11.

Ducrocq, S., Manthi, F. K., & Lihoreau, F. (2011). First record of a parapithecid primate from the Oligocene of Kenya. Journal of Human Evolution, 61(3), 327–331.

Eckert, K. L., Bjorndal, K. A., Alberto Abreu-Grobois, F., and Donnelly, M. (1999). Research and Management Techniques for the Conservation of Sea Turtles. Pennsylavia, USA: IUCN/SSC Marine Turtle Specialist Group Publication No. 4.

Evans, D. R., Carthy, R. R., & Ceriani, S. A. (2019). Migration routes, foraging behavior, and site fidelity of loggerhead sea turtles (Caretta caretta) satellite tracked from a globally important rookery. Marine Biology, 166(10), 35-42.

FRAZIER J-1980- Exploration of marine turtles in the Indian ocean 13:164-175

Gaffney, E. S., and Meylan, P. A. (1988). A phylogeny of turtles, p.157-219. In: M. J. Benton (Editor), The Phylogeny and Classification of Tetrapods. Clarendon Press, Oxford.

Godley, B. J, Broderick, A. C, Glen, F., & Hays, G. C. (2002). Temperature-dependent sex determination of Ascension Island green turtles. Mar Ecol Prog Ser 226: 115−124.

Hays, G. C., Cerritelli, G., Esteban, N., Rattray, A., & Luschi, P. (2020). Open Ocean Reorientation and Challenges of Island Finding by Sea Turtles during Long-Distance Migration. Current Biology, 30(16), 3236-3242.e3.

Hays, G. C., Mortimer, J. A., Rattray, A., Shimada, T., & Esteban, N. (2021). High accuracy tracking reveals how small conservation areas can protect marine megafauna. Ecological Applications, 31(7), 10-23.

Highlights of KEMRI Marine Research and Innovation F.Y. 2020/2011

Hossain, S., & Heo, G. J. (2021). Pet-turtles: a potential source of human pathogenic bacteria. Archives of Microbiology, 203(7), 3785–3792.

IUCN (2015) The IUCN Red List of Threatened Species v. 2015.3. Http://www.iucnredlist.org [accessed 22nd November 2021].

IUCN, (2004). 2004 IUCN Red List of threatened species. http://www.redlist.org. Accessed 22nd November 2021.

Jeantet, L., Planas-Bielsa, V., Benhamou, S., Geiger, S., Martin, J., Siegwalt, F., Lelong, P., Gresser, J., Etienne, D., Hiélard, G., Arque, A., Regis, S., Lecerf, N., Frouin, C., Benhalilou, A., Murgale, C., Maillet, T., Andreani, L., Campistron, G., … Chevallier, D. (2020). Behavioural inference from signal processing using animal-borne multi-sensor loggers: a novel solution to extend the knowledge of sea turtle ecology. Royal Society Open Science, 7(5).

Jensen, M. P, Bell, I., Limpus, C. J., Hamann, M., Ambar, S., Whap, T., David, C. & Fitzsimmons, N. N. (2016). Spatial and tem¬poral genetic variation among size classes of green turtles (Chelonia mydas) provides information on oceanic dispersal and population dynamics, Marine Ecology Progress Series 543: 241-256.

Jensen, M. P., Dalleau, M., Gaspar, P., Lalire, M., Jean, C., Ciccione, S., Mortimer, J. A., Quillard, M., Taquet, C., Wamukota, A., Leroux, G., & Bourjea, J. (2020). Seascape Genetics and the Spatial Ecology of Juvenile Green Turtles. Genes, 11(3).

Kitayama, C., Ueda, K., Omata, M., Tomita, T., Fukada, S., Murakami, S., Tanaka, Y., Kaji, A., Kondo, S., Suganuma, H., Aiko, Y., Fujimoto, A., Kawai, Y. K., Yanagawa, M., & Kondoh, D. (2021). Morphological features of the nasal cavities of hawksbill, olive ridley, and black sea turtles: Comparative studies with green, loggerhead and leatherback sea turtles. PLoS ONE, 16(4 April 2021).

Lasala, J. A., Hughes, C., & Wyneken, J. (2020). Female loggerhead sea turtles (Caretta caretta L.) rarely remate during nesting season. Ecology and Evolution, 10(1), 163–174.

Leakey, M., Grossman, A., Gutiérrez, M., & Fleagle, J. G. (2011). Faunal Change in the Turkana Basin during the Late Oligocene and Miocene. Evolutionary Anthropology, 20(6), 238–253.

Leduc, A. O. H. C., & Hussey, N. E. (2019). Evaluation of pay-for-release conservation incentives for unintentionally caught threatened species. Conservation Biology, 33(4), 953–961.

Limpus, C. J and Miller, J. D. (1993). Family Cheloniidae, in Fauna of Australia, volume 2A Amphibia and reptilia. Australian Government Publishing Service, Canberra, Australia.

Limpus, C. J and Reimer, D. (1990). The loggerhead turtle, Caretta Caretta, in Queensland: A population in decline. In Proceedings of The Australian Marine Turtle Conservation Workshop. Sea World NARA Resort, Gold Coast, 14-17, November. Queensland Department of Environment and Heritage and Australian Nature Conservation Agency, Brisbane, Australia.

Limpus, C. J. (1991). Marine turtles. In R. Baker (ed.), Fantastic Journeys - The Marvels of Animal Migration. Merehurst, London, U.K.

Lyson, T. R., Joyce, W. G., Knauss, G. E., & Pearson, D. A. (2011). Boremys (Testudines, Baenidae) from the latest cretaceous and early Paleocene of North Dakota: An 11-million-year range extension and additional K/T survivor. Journal of vertebrate paleontology 31(4):1-9.

McCLANAHAN T. R. (1997). Effects of fishing and reef structure on East Africa coral reefs. Proceedings of the International Coral Reef Symposium 8: 1533-1538.

McLellan, E., Arps, E., Donelly, M., Leslie, A. (2012). WWF Global Marine Turtle Strategy 2.0 2012 - 2020. 52 pp.

Miller, E. A., McClenachan, L., Uni, Y., Phocas, G., Hagemann, M. E., & Van Houtan, K. S. (2019). The historical development of complex global trafficking networks for marine wildlife. Science Advances, 5(3).

MOCLANAHAN T.R and D OBURA 1994-Status of Kenyan coral reefs coastal management 23:57-76

Molter, C. M., Norton, T. M., Hoopes, L. A., Nelson, S. E., Kaylor, M., Hupp, A., Thomas, R., Kemler, E., Kass, P. H., Arendt, M. D., Koutsos, E. A., & Page-Karjian, A. (2021). Health and nutrition of loggerhead sea turtles (Caretta caretta) in the southeastern United States. Journal of Animal Physiology and Animal Nutrition 3, jpn.13575.

Monsinjon, J. R., Wyneken, J., Rusenko, K., Lopez-Mendilaharsu, M., Lara, P., Santos, A., dei Marcovaldi, M. A. G., Fuentes, M. P. B.., Kaska, Y., Tucek, J., Nel, R., Williams, K. L., LeBlanc, A., Rostal, D., Guillon, J., & Girondot, M. (2019). The climatic debt of loggerhead sea turtle populations in a warming world. Ecol Indic 107: 105657.

Morley et al., (2011) OSEA (Marine Turtles Memorandum of understanding – National Reporting 2019 ()

Musick, J. A., and Limpus, C. J. (1997). Habitat utilization and migration in juvenile sea turtle, in P. L. Lutz, and J. A. Musick (eds), Biology of Sea Turtles. CRC Marine Science Series. CRC Press, Inc, Boca Raton, USA.

MWANJE, J. I. (1997). Socio-economic impacts of coastal instability (Erosion) in Kenya: A Case Study. In: Sustainable Coastal Development through Integrated Planning and Management Focused on Mitigating the Impacts of Coastline Instability. Whitesands Hotel, Mombasa, 23-25 June 1997. UNESCO, Nairobi, Kenya. Pp 26-40.

NEMA (2011). Kenya State of the Environment and Outlook 2010. Supporting the Delivery of Vision 2030. ISBN: 9966-7460-5-6.

Obare, F. D., Chira, R., Sigana, D., Wamukota, A. (2019). Biophysical factors influencing the choice of nesting sites by the green turtle (Chelonia mydas) on the Kenyan coast. WIO Journal of Marine Science 18 (2), 45-55.

Olendo, M., Munga, C. N., Okemwa, G. M., Ong'anda, H., Mulupi, L., Mwasi, L., & Mohamed, H. (2016). Current status of sea turtle protection in Lamu Seascape, Kenya: Trends in nesting, nest predation, and stranding levels. WIO Journal of Marine Science 15(1);1-13.

Patricio, A. R, Varela, M. R, Barbosa, C., Broderick, A. C., Catry, P., Hawkes, L. A., Regalla, A., & Godley, B. J. (2019) Climate change resilience of a globally important sea turtle nesting population. Glob Change Biol 25: 522−535.

Patricio, A. R., Hawkes, L. A., Monsinjon, J. R., Godley, B. J., & Fuentes, M.P.B. (2021). Climate change and marine turtles: recent advances and future directions. Endang Species Res, Vol. 44: 363-395.

Putman, N. F., Seney, E. E., Verley, P., Shaver, D. J., López-Castro, M. C., Cook, M., Guzmán, V., Brost, B., Ceriani, S. A., Mirón, R. de J. G. D., Peña, L. J., Tzeek, M., Valverde, R. A., Cantón, C. C. G., Howell, L., Ravell Ley, J. A., Tumlin, M. C., Teas, W. G., Caillouet, C. W., … Mansfield, K. L. (2020). Predicted distributions and abundances of the sea turtle 'lost years' in the western North Atlantic Ocean. Ecography, 43(4), 506–517.

Rhodin, A., Pritchard, P., van Dijk, P. P., Saumure, R., Bury, B., & Germano, D. (2008). Conservation Biology of Freshwater Turtles and Tortoises. Chelonian Research Monographs, No. 5, 5(Schmidt 1953), e001.1-001.9.

Senko, J. F., Nelms, S. E., Reavis, J. L., Witherington, B., Godley, B. J., & Wallace, B. P. (2020). Understanding individual and population-level effects of plastic pollution on marine megafauna. Endangered Species Research, 43, 234–252.

Shimada, T., Limpus, C. J., Hamann, M., Bell, I., Esteban, N., Groom, R., & Hays, G. C. (2020). Fidelity to foraging sites after long migrations. Journal of Animal Ecology, 89(4), 1008–1016.

Tanner, C. E., Marco, A., Martins, S., Abella-Perez, E., Hawkes, L. A (2019). Highly feminized sex ratio estimations for the world's third-largest nesting aggregation of the loggerhead sea turtle. Mar Ecol Prog Ser 621: 209−219.

Tisdell, C. A., & Wilson, C. (2002). Economic, Educational, and Conservation Benefits of Sea Turtle Based Ecotourism: A study focused on Mon Repos. Wildlife Tourism Research Report Series: No. 20.

UNEP. (1998). Eastern Africa Atlas of Coastal Resources: Kenya (EAF/14) United Nations Environment Program, Kenya 119pp.

Valdivia, A., Wolf, S., & Suckling, K. (2019). Marine mammals and sea turtles listed under the U.S. Endangered Species Act are recovering. PLoS ONE, 14(1).

van der Zee, J. P., Christianen, M. J. A., Bérubé, M., Nava, M., Schut, K., Humber, F., Alfaro-Núñez, A., Becking, L. E., & Palsbøll, P. J. (2021). The population genomic structure of green turtles (Chelonia mydas) suggests a warm-water corridor for tropical marine fauna

between the Atlantic and Indian oceans during the last interglacial. Heredity, 127(6), 510–521.

Walker, T. A., and Parmenter, C. J. (1990). Absence of a pelagic phase in the life cycle of the flatback turtle, Natator depressa (Garman). Journal of Biogeography 17:275-278.

WAMUKOYA, G. M and J.R MBENDO 1995, incidental capture of sea turtles in shrimp trawl fisheries in Kenya KWS Technical Report Services

WAMUKOYA, G.M., F.P. KALOKI & J.R. MBENDO. (1997). Sea Turtle Recovery Action Plan for Kenya (STRAP). KESCOM Technical Report Series. 69pp.

WAMUKOYA, G.M., J.M. MIRANGI & W.K. OTTICHILLO. (1996). Marine aerial survey; marine mammals, sea turtles, sharks and rays, KWS Technical Series Report 1:22pp.

Witt, M. J., Hawkes, L. A., Godfrey, M. H, Godley, B. J., Broderick, A. C. (2010). Predicting the impacts of climate change on a globally distributed species: the case of the loggerhead turtle. J Exp Biol 213: 901−911.

Yang, C. E., Yeh, T. M., Chang, C. D., & Shih, W. L. (2021). Chinese Soft-Shelled Turtle Oil in Combination With Swimming Training Improves Spatial Memory and Sports Performance of Aging Rats. Frontiers in Physiology, 12.

ZANHRER, (2001): moratorium Declared on Trawling Kenya Waters – Marine Turtle Newsletter pg 91.14