UNIVERSITY OF CAPE COAST

STATUS AND CONSERVATION OF NESTING TURTLES ON THE EASTERN COAST OF GHANA

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BY

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Thesis submitted to the Department of Fisheries and Aquatic Sciences of the School of Biological Sciences, College of Agriculture and Natural Sciences, University of Cape Coast, in partial fulfillment of the requirements for the award of Doctor of Philosophy degree in Integrated Coastal Zone Management

FEBRUARY 2023

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature.................................... Date..........................

Name:……………………………………………..……………………

Supervisor's Signature

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's: Signature............................... Date.........................

Name……………………………………………………….…………………...

Co – Supervisor's: Signature.............................. Date..................................

Name…………………………………………….…………………………...

ABSTRACT

Shoreline characteristics and turtle nesting activities on the eastern coast of Ghana was investigated between April 2017 and March 2019. Physical parameters of the beach, distribution, abundance, morphometric data of turtles and nesting activities were monitored within the study areas. Four species of turtles, namely, Olive ridley turtle *(Lepidochelys olivacea)*, Leatherback turtle (*Dermochelys coriacea*), Green turtle (*Chelonia mydas*) and hawksbill turtle (*Erectmochelys. imbricata)* were encountered. An aggregate of 1,397 and 632 turtle activities occurred at Songor Ramsar Site (SRS) and Keta Lagoon Complex Ramsar Site (KLCRS) respectively. Activities of Olive ridley turtles were well distributed in SRS with 2.95 nests per kilometer. Leatherback turtles were common in KLCRS with 2.93 nests per kilometer. Predators of turtle eggs were mostly dogs, ghost crabs, pigs and humans. Dogs were most successful egg predators accounting for 23.6% and 16.6% egg predations in SRS and KLCRS. Olive ridley nests were vulnerable to predation, accounting for 56.2% of total nests predated. A total of 1,183 crawling gaits and nests were encountered, of these 60.4% and 39.6% occurred in SRS and KLCRS. Out of 545 dead turtles encountered, 97.98% occurred in SRS whiles 2.01% occurred in KLCRS. Variations occurred in the sex of the dead turtle encountered during 2017 - 2018 ($p = 0.038$). Leatherbacks were preferred species poached accounting for 93.9% of total poached turtles with monthly and annual poaching rate of 2.03 and 0.37 respectively. Unstable shoreline dictated by high to moderately low erosion, accretion and sand dunes influenced turtle activities. Nesting activities were high when dunes height and erosion were low whiles accretion was high and vice versa. Beach illuminated by artificial lights influenced nesting trends with over 75% of turtle nesting activities occurring in darker and isolated beaches. Recommendations for improving data collection, reducing effect of shoreline changes and involvement of stakeholders to protect turtles are made.

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DEDICATION

This work is wholly dedicated to my family, my wife, Elizabeth, my children - Nancy, Betty, Maame Esi, Dickson (Jnr) and David.

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CHAPTER ONE

INTRODUCTION

Background to the Study

Beaches are ecosystems that provide suitable habitat for many marine animal species that have adapted to the constant motion of the sand and gravels. Diverse species of marine animals feed, nest, and roost on the berm and open beach. Removal of sand from the beach could trigger serious erosion and aggravate beach degradation processes. Continual erosion and accretion modify the coast and could interfere in the nesting patterns of marine turtles and other marine species. Unpolluted, natural and well-nourished beach is ideal for turtle nesting activities that could also sustain the global turtle population.

Turtles in the wider marine environment face diverse threats. The situation is more precarious when they emerge to nest on the beaches. Approximately 42,000 threatened sea turtles are killed around the world each year through illegal hunting in 42 countries including Australia, Japan and Mexico, Papua New Guinea etc. (Dominque, 2016). Since 1980, it‘s estimated that more than 2 million turtles have been legally taken in these countries (Dominque, 2016). The global concern of current marine turtle mortality has mainly been the threats from illegal fisheries, by-catch and direct take.

All over the world, the population of sea turtles is declining and the situation is not different for Ghana (Agyeman et al., 2013). The sea turtle population, as has been observed is declining both in the waters and on the nesting beaches of Ghana. There is also the possible extirpation of some species of sea turtles that once used Ghana’s sandy beaches as their nesting habitats.

The green turtle *(Chelonia mydas)*, loggerhead turtle (C*aretta caretta)* and the hawksbill *(Eretmochelys imbricata)* turtle are believed to have once nested on the beaches of Ghana. These turtles are not commonly sighted on most nesting beaches of Ghana (Agyeman et al., 2013). Turtles face similar threat as other species that utilize unstable, modified and degraded beach as nesting grounds.

The unplanned activities along the fragile coastal ecosystem pose major threats to biodiversity and sustainable livelihood. Threats to marine turtles include the loss of nesting beaches due to human development, poaching and degradation of foraging sites. Modification of coastline could negatively affect marine resources and in the long term results in the rapid dwindling of community resources and livelihood.

Coastal Ecosystems

More than 60% of the world's population lives within 60 Km of the coast. (Coastlearn, 2016). The excessive exploitation of the natural resources and the increase population growth have put enormous pressure on the coastal ecosystems and this has resulted in biodiversity loss and ecosystem degradation. Coastal areas support a variety of productive habitats: mangroves, marshes, mudflats, sea grass, seaweed beds and coral reefs. Variety of activities are concentrated in the coastal areas such as industry, human settlements, aquaculture and tourism development. Enormous pressure has been placed on the coastal area escalating changes in the land use patterns. Over the years, marine resources have become degraded (MEWR, April 2014). The negative impacts have been as a result of excessive exploitation of marine and coastal resources. Global climate change and climate variability adds to the continuous pressure on these coastal environments. Coastal ecosystems act as the backbone of most local economies and perform other useful functions such as filtering organic waste and mitigating coastal erosion. They provide ecosystem services and serve as an irreplaceable source of genetic biodiversity, educational, scientific and aesthetic pleasure.

Coastal ecosystems are being lost at a rapid rate globally and no tropical region seems free of risks of erosion. Excessive sea waves have depleted sand bars and dunes, rendering most coastal zones ineffective in the provision and sustenance of environmental processes and services. Erosive forces of the sea has disrupted livelihood activities, destroyed properties and displaced settlers along the coastline, estuary and island communities. Over 20% of the coastline in the Greater Accra Region in Ghana is critically threatened. Roads have been washed away in the Volta Region and coastal lagoons are under threat from various natural and man-made pressures. Annual erosion rate of Ghana's coast is between 2.88 m and 4 m (moderate), rate between 1.77 m and 2.7 m and between 0.05 m and 1.6 m (low) (Ekow et al., 2016).

Regulatory Instruments on Turtle Conservation

Ghana is a signatory to many conservation protocols that seek to protect and preserve biodiversity and their fragile ecosystem. The Convention on the Conservation of Migratory Species of Wild Animals (CMS), Convention on International Trade in Endangered species (CITES) and Convention on Biodiversity (CBD) all aimed at globally protecting biodiversity across boarders including migratory sea turtles. The fundamental objective of the Bonn

Convention of 1972, also known as the Convection on the Conservation of Migratory Species of Wild Animals (CMS), was to protect migratory species by Range States. This practically has not been achieved by many states due to several challenges, which include inadequate financial resources and human capacity.

Marine turtles are listed in the first schedules of the Wildlife Conservation Regulation L.I 685 of 1971 (Wildlife Division, 2002), which provides complete protection for sea turtles. Turtles are therefore not to be hunted, captured or destroyed. However, turtles captured accidentally as by–catch during fishing expeditions are never released except in areas where consumption of the turtle meat is prohibited by traditional norms.

Traditional beliefs and taboos in Ghanaian communities normally have no legal backing. This phenomenon however has power to influence and the ability to command the respect and belief from community members. Ecosystems and species associated with such taboos and traditional beliefs are revered and protected. In Ghana, marine turtles are protected by traditional norms in Ada, Ningo and Prampram. This makes the area important for marine turtle conservation. Marine turtles in such communities possess strong religious and cultural values (Agyeman, 2008).

Problem Statement

Songor and Keta Lagoon Complex Ramsar Sites are two adjoining conservation areas with considerable stretch of coastline that has undergone tremendous modification over the years. The two sites are noted for considerable turtle nesting activities. However, nesting turtles are threatened by human activities. The shoreline dynamics also influence nesting patterns and survival of emergent turtles. The two sites are designated protected areas (Ramsar sites) under the Wildlife Division of the Forestry Commission but inadequate data on nesting turtles and other species limits management measures on biodiversity. There is research gap in turtle conservation activities in Ghana which include population trends, impact of habitat changes and poaching. Data on turtle nesting and conservation activities is deficient, fragmented and in the nascent stage.

Justification of the study

Baseline information for future assessment and research opportunities that will bridge the knowledge gap and address challenges linked to the extirpation of endangered turtles on the shoreline of the two sites are deficient and uncoordinated. Unsustainable use of our marine resources may not compliment the global efforts to protect the oceans and biodiversity, which also falls within the Sustainable Development Goal 14, target 14.2; by 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration, to achieve healthy and productive oceans (UN, 2014). Diverse threats to the marine species outside the wider sea require adequate interrogation. The extent of coastal degradation within the study areas and the assessment of the impact on emerging turtles, other critical resources and livelihoods of the coastal communities requires quality and reliable data from integrated ecosystem assessment. Ghana is a signatory to diverse international conservation protocols. The level of protection of the marine species within the framework of international conventions, bilateral protocols, national legislations and local conservation practices need assessment. The study will provide data for effective management mechanism to regulate marine resource exploitation including marine turtles in communities within the study areas. Information and pragmatic intervention strategies that could lead to effective coastal resource management through collaborative effort will be promulgated after the study.

Research Objectives

Aim of the Study

The study was to examine the status and conservation of nesting turtles on the eastern coast of Ghana.

The specific study objectives were to:

i determine species of turtles that emerge on the beach and assess the morphometric parameters.

ii determine the distribution, abundance and density of turtles and nesting activities.

iii examine threats associated with nesting and stranded turtles.

iv assesses the changes along the shoreline, the physical structures formed and evaluate the impacts on emergent turtle activities.

v evaluate the conditions influencing the selection of nesting sites of turtles

Significance of the Study

This research will benefit coastal and marine resource users, managers and policy makers in the areas of conservation and socio-economic development. The results obtained will contribute to scientific knowledge relevant for decision making in the protection of critical ecosystems and vulnerable species. The result will also provide the platform for sensitizing the communities about laws and international conventions that Ghana has signed on to protect nesting turtles and their nesting habitats. The study will serve as a baseline for future monitoring and evaluation of management interventions towards improving turtle conservation in Ghana. It will form a basis for future comparable scientific studies in Ghana and neighbouring sub region.

Hypothesis

Ecosystem changes within the beach of the eastern coast of Ghana affect nesting turtles, their nest and hatchlings. Available regulations have not been effective in the conservation of nesting turtles along the beach.

Based on the above hypothesis, the predictions to be tested may be stated as follows:

- There is significant difference in levels of ecosystem changes within the beach.
- There is significantly different level of effect of ecosystem changes on nesting turtles, their nests and hatchlings.
- Available regulation influences the conservation of nesting turtles.

Based on the above predictions, the null hypotheses to be tested were:

- There is no significant statistical difference in ecosystem changes along the beach
- There is no significant statistical difference in the influence of ecosystem changes on nesting turtles, their nests and hatchlings.
- Available regulations do not significantly influence conservation of nesting turtles.

CHAPTER TWO

LITERATURE REVIEW

Coastal Interacting Systems

Marine turtles are thought to be numerous along much of the Atlantic coast of Africa, extending some 14,000 km from Morocco to South Africa, including nesting sites, feeding areas and migration corridors of importance for six species: *Caretta caretta*, *Lepidochelys kempii*, *Lepidochelys olivacea, Chelonia mydas, Eretmochelys imbricata* and *Dermochelys coriacea*. Excessive exploitation, both direct and incidental and degradation of essential habitats are thought to be among the most important factors causing the depletion of their numbers (UNEP/CMS, 2000).

Sea turtle mortality can be attributed to variety of causes and these include natural and anthropogenic. Natural causes include aging, predation, sickness, starvation and meteorological phenomena (Jacque 2001). The effects of these maintain the population's growth in balance. Anthropogenic causes can have effects that produce instability in the populations and can even bring them to extinction. These include pollution, poaching and bycatch (Jacque et al., 2022).

The diversity of ocean ecosystems favours the development of abundant fauna, including marine turtles, which are well distributed throughout the tropical and temperate waters. The habitats preferred by these species range from wide prairies, with abundant sea grass and marine algae, to the rocky-sandy bottom and coralline areas rich in bottom- dwelling organisms.

Marine coasts are dynamic environments which undergo constant changes. The main agents responsible for deposition and erosion along coastlines are waves, tides and currents. The formation of coasts also depends on the nature of the rocks they are made of; the harder the rocks the less likely they are to erode. Variations in rock hardness result in coastlines with different shapes (Coastlearn, 2016). The important implications for sea turtles are how they might respond to the future loss and gain of the nesting beaches. Marine turtles are vulnerable to beach habitat loss that might occur under climatic changes. Sea turtles can therefore move into and out of regions in response to climate change. They can adjust to warming trends by shifting their ranges into higher latitudes, but this shift is only possible on a sandy coastline. Higher latitude coastlines are mainly dominated by rocky habitats with few beaches. Thus, as turtles move away from the tropics under future warming scenarios, they might have nowhere to go (Scott et al., 2007). How sea turtles select nesting beaches still remains a topic of scientific curiosity. Habitat shifts can affect movements and nesting behaviours of turtles.

The human–sea turtle interactions, however, are mostly not well known. Ethnographic and historic reports documenting these interactions are scattered requiring extensive archival research. Sea turtles are however revered in many cultures. Around the world there are numerous indigenous tales and legends that depicts turtles as guardians or creators of life on earth (Arturo *et al.,* 2009).

Whilst interest in basic research and conservation activities in a number of countries have grown considerably in recent years, the gaps in knowledge of marine turtle distribution and abundance remain vast, and efforts to coordinate conservation programms among countries are still at a nascent stage. Reviewing the conservation status of marine turtles in territories concerned could enhance the avenue to explore the potential areas of collaboration and protection.

Global Distribution of Turtle Species

Species and sub species of marine turtles are distributed throughout the tropical and subtropical seas. Different species of turtles have different requirements during reproductive periods, during their migration to feeding grounds, in the areas of growth and migratory corridors. Consequently, they are not distributed in a homogeneous way. There are areas of great abundance and areas of low density or total absence (Jacque et al., 2022). As far as distribution of turtles is concerned, the western part of the Atlantic Ocean has more areas of major importance than the eastern part, but perhaps this also reflects the fact that more studies have been conducted in the western Atlantic than elsewhere and research is more advanced in the Western Atlantic. Accordingly, information on fisheries, biology and related aspects is more abundant for the western part of the Atlantic and difficult to obtain for the eastern part (Barbosa, 2018).

The different species and subspecies of marine turtles can be differentiated by their morphology, behavioral and geographical distribution. *Lepidochelys olivacea* are solid olive grey above and creamy or whitish with pale grey edges below. Adult shell is very round, a little turned up at the marginals and flat on the top. The width of the shell represents 90% of its length. The average straight length of the shell of adults of both sexes varies from 51 to 79 cm (average: 67 .6 cm). *Chelonia mydas* head is relatively small with a typically rounded snout. On the upper side, among adults, the general co- lor varies from pale greenish brown to very dark. The average size of adults is 99 cm with a weight of 145 kg. The records for height and weight are 139.5 cm and 235 kg respectively. *Eretmochelys imbricata* has cordiform or elliptical carapace in adults, its width being about 74% of the total length. Head rather small, with a long and narrow muzzle. The beaks are not serrated but hooked. The average straight carapace length of adult females ranges from 53 to 114 cm (Jacque et al., 2022). A heart-shaped carapace in its dorsal view characterizes the adult *caretta caretta*. Its width is about 76 to 86% of its length. The head is large with strong jaws and comparatively thicker horny beaks than in other marine turtles. *Dermochelys coriacea* has reduced external keratinous structures. The scales are temporary and disappear in the first months after hatching. The whole body is covered with a smooth skin, although traces of scales can remain on the eyelids, the neck and the caudal crest (Jacque et al., 2022).

Another particularity of the populations is the tendency to come together periodically in the feeding grounds. They also display great fidelity, returning to the same beach season after season to reproduce. Recent genetic studies have shown that populations can mix in the feeding grounds, which makes it even more difficult to study them. Marine turtle nesting site; are relatively well identified and monitored in areas with advance technology such as the Eastern United States and Mexico, the Caribbean, Central American and the Atlantic Coast of South America. Marine turtles are highly migratory species although some species abound in particular regions. The Mediterranean region is an important area for *Caretta caretta* and *Chelonia mydas. Dermochelys coriacea* is generally distributed in the whole region, although regular reproduction has not been observed. Some other turtle species, such as *Eretmochelys imbricata* and *Lepidochelys kempii* have also been observed occasionally (Jacque et al., 2022). In the Indian Ocean six species of marine turtles have been recorded.

These include *Chelonia mydas*, *Eretmochelys imbricata*, *Caretta caretta*, *Lepidochelys olivacea*, *Dermochelys coriacea* and the flat back (*Natator depressus*). Six species of marine turtles occur in the Pacific Ocean – *Chelonia mydas, Caretta caretta*, *Dermochelys coriacea*, *Eretmochelys imbricata, Lepidochelys olivacea* and *Natator depressus*. All species, except *Natator depressus*, have trans- boundary distributions (Fretey, 2001). Though six species of marine turtles occur in the Atlantic coast of Africa of which Ghana forms part, only three of these turtle species currently commonly occur on the coast of Ghana. These include *Dermochelys coriacea, Lepidochelys olivacea* and *Chelonia mydas*.

Threats and Trends of Sea Turtle Mortality

Once abundant, marine turtle populations now are a fraction of what they once were. *Dermochelys coriacea* has survived more than a hundred million years, but now is facing extinction. Recent estimates of numbers show that this species is declining precipitously throughout its range (Harvey, 2018). Threats to marine turtles include the loss of nesting beaches to human development; harvest and poaching of turtles for their eggs, meat, and shell; man-made disasters such as oil spills; accidentally or intentional capture in fishing nets, trawls and hooks; and the degradation of grass beds and coral reefs that they rely on (Barbosa, 2018). Sea turtles are caught worldwide, although it is illegal to hunt most species in many countries. A great deal of intentional sea turtle harvests worldwide is for food. Ancient Chinese texts dating to the fifth century, described sea turtles as exotic delicacies (Scott et al., 2007). Many coastal communities around the world depend on sea turtles as a source of protein, often harvesting several sea turtles at once and keeping them alive on their backs until needed.

Sea turtles and their eggs have in general been exploited over many centuries in a sustainable way. They were part of the daily diet in the villages along the coast, especially the green turtle *(C. mydas*), which was even exported in the last century from, for instance Mexico, Costa Rica and Nicaragua to the United States (Fretey, 2001). The leather and oil of this species and of the loggerhead *(C. caretta)* were marketed in the region and handicrafts decorated with tortoiseshell of the hawksbill turtle *(E. imbricata)* were sought after. In Mexico, as in many other countries, commercial exploitation was carried out using special nets and harpoons. Some turtles were caught illegally during the nesting season. According, to the level of commercial turtle capture registered in Mexico in 1964 and 1981, the Green turtle accounted for 67.9% in 17 years, the loggerhead 24.8% in 13 years, the hawksbill 1.13% in 9 years, Leatherback 5.56% in 8 years and Olive ridley 0.6% in 7 years. In the missing years for these data, either there were no captures or data were not registered (FAO, 2004). In 1972, a total ban was declared and permits for commercial capture started to be issued again in mid - 1973. After 1981 the government did not grant any more catch permits for the east coast and the statistical information were no longer recorded. Finally, in 1990 a new ordinance prohibited the capture and use of sea turtles throughout the year (FAO, 2004).

Specific species of marine turtles are targeted not for their flesh, but for their shells. Tortoiseshell, a traditional decorative ornamental material used in Japan and China, comes from the carapace scutes of the hawksbill turtles. Ancient Greeks and Romans processed sea turtle scutes, primarily from the hawksbill for various articles and ornaments used by their elites, such as combs and brushes. The skin of the flippers is prized for use as shoes and assorted leather goods (FAO, 2004). One of the most significant threats now comes from bycatch due to imprecise fishing methods. Long-lining has been identified as a major cause of accidental sea turtle death (Scott et al., 2007). Sea turtles must surface to breathe. Caught in a fisherman's net, they are unable to surface and thus drown. In early 2007, almost a thousand sea turtles were killed inadvertently in the Bay of Bengal over the course of a few months after netting (FAO, 2004). There is a black-market demand for tortoiseshell for both decoration and supposed health benefits. Another major threat to sea turtles is black-market trade in eggs and meat. This is a problem throughout the world, but especially a concern in China, the Philippines, India, Indonesia and the coastal nations of Latin America. Estimates reach as high as 35,000 sea turtles killed a year in Mexico and the same number in Nicaragua (Dominique, 2014). It is estimated that at least 1.1 million sea turtles were illegally caught between 1990 and 2020 globally (Steiner, 2022).

Despite increased national and international protection of marine turtles, direct legal take remains a major source of mortality. However, it is likely that a fraction of current marine turtle mortality take is legal, with much greater threats from illegal fisheries and bycatch. The high number of the animals being killed legally, as well as the continued illegal trade of turtle products and the number of turtles killed as a result of commercial fishing for other species, are all bad news for turtles (Dominique, 2014).

Causes of Mortality

Mortality in sea turtles is attributed to a variety of causes. Natural sources include aging, predation, disease infections, starvation and meteorological phenomena which regulate population growth. However, anthropogenic factors can produce instability in the populations and possibly extinction.

Natural causes

Turtle death may affect current population that nest on the beach and future recoupment. Turtles may be affected by hurricanes, high tides, extreme temperatures and humidity during the short period on land. In the sea the level of predation is high in all the initial phase of development and it continues during the long migrations between the feeding grounds and nesting areas. Such journeys last more than one year (FAO, 2004). The growth of the individual and the population depends on many factors such as food quality / availability, genetic factors, temperature and illness. In general, almost all the sea turtle species that reach maturity in the tropical areas do so between the ages of 10 and 20. During migration, sea turtles can be preyed upon or become weakened by the effort, which can increase mortality. A large number of turtles die every year and are stranded on the beaches. Nearly all the turtles encountered are immature and it is nearly impossible to determine the cause of death by necropsy (Barbosa et al., 2018).

Predators

Sea turtles, like any living organism, are vulnerable to predation; this vulnerability varies according to the developmental stage and the kind of predator. Obviously, one of the most vulnerable stages is the egg phase ((Jacque et al., 2022). The most important loss, including those for which human beings are responsible, takes place during or immediately after laying the eggs on the beach. The beaches are constantly searched by dogs and pigs solitary places to prey on the eggs in the nests. If there are some remains of the eggs and hatchlings in nests that have been opened, they are devoured by birds of prey, crabs and ants. (Jacque 2001).

Hatchlings are vulnerable to predation, especially when they emerged during the day, since they can be decimated when they emerged from the nest and crawl to the sea, which can be a journey of several meters. They usually emerge between the evening and dawn. During this brief period, the hatchlings are attacked by crabs or devoured by mammals, such as feral dogs and pigs or birds such as night heron *(Nicticorax)*, gulls, eaglets, auras *(Catartes)*, vultures *(Coragyps*), ravens and crows (Arturo *et al.*, 2009). However, it is logical to suppose that as the turtles increase in size, the variety of possible predators narrows.

Natural Habitat Changes

Meteorological phenomena can occasionally destroy all the nest on a beach, either through flooding, erosion or excess rain (Scott et al., 2007). The death toll may be greater if such an event happens during the peak of the nesting season or when hatching occurs. High tides that cover the beaches for several days, may cause the death of the eggs and the hatchlings. Changes in the shape and slope of beaches can modify the turtles' behavior. Beach erosion caused by natural changes and subsequent inundation by high waves, together with the covering of nets by shifting sand dunes are the major reasons for the loss of turtle nests.

Management of Turtle Nest and Eggs

Inappropriate conservation activities

Excessive manipulation of eggs and hatchlings during conservation activities on nesting beaches and combined with lack of knowledge, may cause much mortality among eggs and hatchlings. Excessive manipulation of eggs and hatchlings must be avoided, and hatchlings should be released as soon as they emerge from the sand to avoid inappropriate behavior and introducing them to infections (Marquez, 1990).

Habitat degradation

Degradation caused by humans has been noted at some significant nesting sites. The main anthropogenic threats affecting marine turtles nesting areas include tourism and recreational activities, an increasing human presence, vehicular and pedestrian traffic, beachfront lightning and noise, uncontrolled development and construction, beach pollution, marine pollution, near shore fishing and the use of underwater explosives (Margaritoulis *et al.,* 2003).

Egg exploitation

Egg exploitation generally occur in nearly all the countries of the regions. However, there are no statistics on the volume of this exploitation

(Mrosovsky, 2003). Their harvest volume was never regulated and there are no official records because most of the harvest was clandestine.

Collision with boats

Not all species are affected at the same rates – accidents are more common with juveniles and sub adults of *Chelonia, Lepidochelys* and *caretta*. From samples recovered in the Gulf of Naples, 28.1% turtles had injuries attributed to being struck by boat (Margaritoulis *et al.*, 2003).

Pollution and waste debris

The effects of oil pollution are not known in detail, although turtles can clearly be immobilized and exhausted by heavy contamination. Parts of the Mediterranean are profoundly polluted, little is known of the effects of contamination on marine turtles (Margaritoulis, *et al.*, 2003).

Light pollution

Light disrupts a critical nocturnal behavior of hatchlings crawling from their nest to the sea. Artificial lighting on beaches is strongly attractive to hatchlings and can disorient hatchlings and interfere with their movement towards the sea (Aureggi, 2003b). Conservationists develop ways to identify and minimize problems caused by light pollution.

Oil / Gas Exploration and Exploitation

Oil spills are common, some are caused by oil tankers, some occur in the oil fields by accident and some take place when oil rigs of submarine wells are retired. There is evidence of oil in all the tissues examined and indications that the exposure had been chronic. Comparisons with results of studies done on birds indicate consumption of 50,000 pm or more of oil in the diet of the turtles (FAO, 2004).

Contribution of Fishing to Turtle Mortality

Sea turtle mortality varies with regards to the kind of commercial fishery. Some studies have been undertaken on incidental capture during shrimp trawling and in longline fisheries. The kind of fishing that has had the greatest effect on sea turtles populations has been catches targeting the resource as food, either on the beach or in the sea. The amount of exploitation has been so high that it has taken some populations to the point of extinction and others remain at levels from which they are unlikely to recover (FAO, 2000). Majority of captured turtles are females. The problem is that when turtles are captured off beaches or on nesting beaches, the damage is great, because the population's future recruitment is affected.

Implications of Population Growth on Coastal Areas

Population density

About 50% of the world's human population lives in the coastal zone within 100 km from the sea. The average population density in the coastal zone is twice as high as the global average. More than three billion people rely heavily on coastal and marine ecosystems, habitats and resources for food, building materials and sites, agricultural and recreational areas. The coastal areas are also used as a dumping ground for sewage, garbage, and toxic wastes (Misdorp, 2009).

A large percentage of West Africa's urban population lives in coastal cities. In Nigeria, for example, about 20 million people (22.6% of the national population) live along the coastal zone; about 4.5 million Senegalese (66.6% of the national population) live in the Dakar coastal area (IPCC, 2017). About 90% of the industries in Senegal are located within the Dakar coastal zone. In Ghana, Benin, Togo, Sierra Leone, and Nigeria, most of the economic activities that form the backbone of the national economies are located within the coastal zone. Coastal areas also form the food basket of the region. Offshore and inshore areas, as well as estuaries and lagoons, support artisanal and industrial fisheries accounting for more than 75% of fishery landings in the region. (IPCC, 2017)

The coastal population is growing more rapidly than in inland areas, due to the combined effect of birth rates, migration and large-scale urbanization. Of the world's 33 world megacities (more than 10 million inhabitants), 21 are located in the coastal zone, most of them in Asia (Misdorp, 2009). Coastal urbanization in Asia has been rising faster than in any other continent, especially during the last two decades of the 20th century and this trend is likely to continue to at least 2030. The population pressure on the world coastal zone is seriously damaging the resource base itself in many coastal nations. Coastal urbanisation often involves large-scale pollution and increased risks of flooding due to increased population density and fast, short-term economic development and capital (Misdorp, 2009).

Population Growth and Pressure on Coastal Resources

Many coastal zones of the world have been impacted by human activities and will undergo continued profound changes in the near future. Human use and exploitation of coastal and marine resources has created largely negative impacts on them and through the years they have become degraded. Global climate change and climate variability adds to the continuous pressure on these coastal environments especially in Small Island States (SIS), many of which are faced with a limited resource base, logistical challenges and rising pressures from economic development (ICZM, 2014). The coastal zone is a focal point in many national economies where a large number of social and economic activities and their impacts are concentrated. Industrialization, commercial development and steadily growing population pressure in many places have resulted in an increase of erosion and flooding, degradation and loss of wetlands and other habitats, pollution, and over-exploitation of land and water resources in the coastal zone.

The excessive exploitation of the natural resources and the intensive population growth have put enormous pressure on the coastal ecosystems and this has led to biodiversity loss and ecosystem degradation. Climate change impacts and related sea levels rise and water temperatures are expected to further intensify the threat to the world's coastal zones (Coastlearn, 2016).

Shoreline changes

Issues of coastal erosion are a worldwide problem and sandy beaches around the globe are recessional. Currently, coastal zones are facing intensified natural and anthropogenic disturbances including sea level rise, coastal erosion and over exploitation of natural resources. Over 70% of the world's beaches are experiencing coastal erosion and this presents a serious hazard to many coastal regions (Appeaning - Addo *et al.*, 2011). Shoreline changes occur over a wide range of time and these changes are mainly associated with waves, tides, winds, periodic storms, sea-level change, and the geomorphic processes of erosion and accretion.

Coastal erosion trends in Africa

Coastal erosion has been recognized as one of the most crucial issues along the coast of Western African. Africa is one of the regions whose coastal zones, estuaries and deltas are the most exposed to risks of flooding related to the rise in mean sea level (Nicholls and Tol, 2006). Mining of sand and gravel from estuaries, beaches and directly from the continental shelf contributes to coastal erosion and shoreline retreat. In some cases, construction of ports and harbours perpendicular to the littoral zone can cause acute down-drift erosion. At present, widespread erosion and flooding are devastating vast areas along the African coastline, causing severe ecological problems. A rise in sea level in many places may be accentuated by the phenomenon of subsidence, aggravate the already existing ecological problems through increased rates of coastal erosion, more persistent flooding, loss of wetlands, increased salinization of groundwater and soil as well as greater influx of diverse pollutants.

In West Africa from Mauritania to Benin, rocky coasts represent fewer than 3 % of the coast line. These coasts are made of rock that is often altered and fractured, subject to land- slides and erosion. (Jean-Jacques *et al.*, 2014). On the coasts that is constituted of sedimentary accumulation and the most common in West Africa, the mobility of the shoreline largely depends on the local balance of supply and removal in the sediment budget. Removal operates under the action of natural agents (coastal drift, ocean waves, wind, etc.), which are also partly responsible for sediment supply. Removal may also be the result of human activity, either directly (extraction from the beaches of raw materials for building activities, for instance), or indirectly (the creation of surfaces that reflect wave energy or installations that disrupt the operation and the exchanges between the different sediment compartments of the beaches or that disturb the coastal drift parallel to the shore). The dams situated on the catchment areas also constitute traps for continental sediment which no longer reaches the coast, increasing the sediment deficit, particularly at the level of the estuaries and mouths of rivers (Jean-Jacques et al., 2014). Coastal erosion and increases in the salinity of water and soil, industrial pollution from oil spills and discharge of domestic untreated wastes is polluting large areas of the coast, including lagoons and near-shore areas. The coastal zone of East Africa also will be affected-although, unlike West Africa's Atlantic coast, this area experiences calm conditions through much of the year. Increases in population growth rates in the principal coastal cities of East Africa, combined with a likelihood of a 1-m sea-level rise, could create conditions for significant negative impacts on tourism-oriented economies, ecology, and natural habitats of this area. The consequences remain, however, extremely difficult to evaluate and should only be envisaged through a detailed study of local situations. (Jean-Jacques *et al.*, 2014). Whatever the dispute about the rates of erosion and amounts of sea level rise, it is evident that coastal communities and adjoining ecosystems will need to adapt to these changes. Only three options are available to human beings to combat coastal erosion: retreat, accommodate or protect.

Coastal erosion trends in Ghana

Coastal erosion, flooding and shoreline retreat are serious problems on the coast of Ghana and this occur under natural factors and human influence. Erosion rates increased reaching as high as 8m/year around 1970 (Appeaning - Addo et al., 2011).

According to estimates, the ocean claims 1.5 to 2 m of the 560 km coastline annually; with the most risky areas, Ada Foah and the Eastern parts of Keta, recording 4m (Ofosu Anim et al., 2013). One serious erosion situation was also recorded at Ada Foah Beach. It was estimated that the coastline in the area is eroding at a rate of 4m annually. The government of Ghana embarked on a costly and controversial project to the building of an estimated 68 million euro, 30 km Ada Sea Defense Wall along the 44 km-stretch of the Ada coastline (Ofosu Anim et al., 2013). This project was undertaken to ensure maximum protection of the people and the infrastructure as well as the coastal environment.

There have been interventions such as the Keta Sea Defence Project (KSDP) which involved stabilization of the shoreline with break water and groynes, construction of a flood control structure and land reclamation from the lagoon. These among others have influenced the accretion and erosion patterns along this coast (Appeaning - Addo *et al.*, 2011).

Erosion and recession of the shorelines and beaches pose danger to dwellings near the shoreline, the tourism potential and coastline development is mostly threatened. Erosion in some areas threatens the livelihoods of coastal communities. Fish landing sites have been abandoned and fishing villages need new sites for resettlement.

Shoreline Protection

Several restoration and conservation activities have been practiced locally to address the problem of beach loss, but currently there is no perfect single solution to this problem. Beach nourishment is one management option to restore eroding sandy beaches. However negative impacts of beach nourishment have been documented by Rumbold *et al.,* (2001). This may normally due to beach theft and sand mining for constructional activities.

Modern coastal defences have to satisfy economic and environmental criteria. The criteria make the implementation of coastal defences complicated. Environmental and sustainability considerations have become more prevalent in the implementation of coastal defences. This has often become the governing factors when determining an appropriate sea defence system.

Coastline Protection and Turtle Conservation

Coastal protection measures to date have included piecemeal construction of groynes, sea walls and other physical barriers, often at high costs and in many cases, further contributing to the problem rather than curbing it. Coastal protection solutions can be divided into two major categories of "hard" and "soft" engineering solutions. Hard solutions typically result in permanent structures that have continual effects on the environment. Soft solutions are the environmentally preferred options and do not involve permanent structures (Derek, 2012). Groynes are man-made coastal defence features that limit the effects of longshore drift, reduce erosion and encourage deposition. They usually run perpendicular to the shoreline, extending from the land, down the beach and into the sea. They are very obvious forms of coastal defense and, because they are usually installed in groups, they break beaches up into sections.

Coastal protection structures such as sea walls on or adjacent to nesting beaches can prevent sea turtles from continuing their life cycles. Sea walls directly threaten sea turtles by reducing or degrading suitable nesting habitat. They block turtles access to the upper portion of the beach, causing turtles to nest in less-than-optimal nesting areas lower on the beach where their nests are more susceptible to wave action and more likely to be covered with water (Carr, 2022). In addition, studies have shown that fewer turtles emerge onto beaches with seawalls than onto adjacent, non-walled, natural beaches. Those turtles that do emerge in front of seawalls often return to the water without nesting, known as a false crawl. The rate of false crawls is generally significantly higher in front of sea walls water (Carr, 2022). Groynes constructed with boulders that have sharp edges usually severely lacerate the flippers and plastron of nesting turtles that try to crawl on them.

Global Efforts towards Marine Turtle Protection

Policies and Regulations

Marine turtles are caught worldwide, although it is illegal to hunt most species in many countries. Approximately 42,000 threatened sea turtles are killed around the world each year — and that's counting only the ones captured legally, according to a study from the University of Exeter in the United Kingdom (Dominique, 2014). The data shows that legal hunting of sea turtles is allowed in 42 countries or territories, including Australia, Japan and Mexico. Papua New Guinea is said to be responsible for more than 36 percent of the legally taken turtles every year. Since 1980, it is estimate that more than 2 million turtles have been legally taken in these countries (Dominique, 2014).

Despite increased national and international protection of marine turtles, direct legal take remains a major source of mortality. All seven species of marine turtles are considered threatened in the wild. The Green turtle is considered endangered by the International Union for Conservation of Nature; while the World Wide Fund for Nature (WWF) says that the Leatherback turtle is critically endangered in certain regions of the world (Dominique, 2014).

Because marine turtles migrate vast distances throughout the oceans, successful conservation requires close cooperation among countries sharing the same oceans (U.S Fish & Wildlife Service, 2020). The incentive for the long-term conservation of these species could actually be strengthened through well-managed fisheries operating at a sustainable level, but this also requires good ecological and socio-political understanding as well as adequate regulatory structures at the national and international level (Dominique, 2014).

Conservation Status of Marine Turtles

There are seven species of sea turtles. All seven are listed on Appendix I of the Convention on International Trade in Endangered Species (CITES) and granted its highest level of protection; all seven are also listed as critically endangered, endangered or vulnerable on the IUCN (World Conservation Union) Red List; and six of the seven are listed as endangered or threatened under the U.S. Endangered Species Act (the seventh has been proposed for listing). The only species that currently appears to be increasing in numbers on a global basis is the Kemps ridley turtle, identified by the IUCN in 1986 as one of the 12 most endangered animals in the world (IUCN, 1995). Despite recent modest improvement to the Kemps populations, it is still far below the population size needed for the recovery of the species (IUCN, 1995)

International Treaties, Agreements, and Memoranda of Understanding (MOU)

International treaties, agreements, and memoranda of understanding play an important role in wildlife conservation, particularly for species that defy national boundaries. They hold the potential to surpass the limits of local or regional projects, and to foster international collaboration and cooperation that can facilitate experience sharing and capacity building (Campbell et al., 2002). Evaluating the progress of conservation programs is difficult, because many sea turtle populations have not been assessed adequately. Most information on sea turtle populations comes from counting nests on beaches, but this doesn't provide an accurate picture of the whole sea turtle population. A more detailed information on sea turtles' life cycles, such as birth rates and mortality, is needed.

Memorandum of Understanding Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa

This agreement was signed by 23 states in 1999, under the following declaration. Noting that marine turtles are listed in Appendices I and II of the Convention on the Conservation of Migratory Species of Wild Animals and, therefore, are the object of concerted and co- operative actions under that Convention;

Endeavour to put in place measures for the conservation and where necessary and appropriate, strict protection of marine turtles at all stages of their life cycle (including eggs, hatchlings, juveniles, sub- adults and adults).

Convention on the Conservation of Migratory Species of Wild Animals

This convention was signed in Bonn on 23 June 1979 under the following declaration.

AWARE that each generation of man holds the resources of the earth for future generations and has an obligation to ensure that this legacy is conserved and, where utilized, is used wisely;

CONVINCED that conservation and effective management of migratory species of wild animals require the concerted action of all States within the national jurisdictional boundaries of which such species spend any part of their life cycle;

Parties that are Range States of a migratory species listed in Appendix I shall prohibit the taking of animals belonging to such species. Exceptions may be made to this prohibition only if:

- the taking is for scientific purposes;
- the taking is for the purpose of enhancing the propagation or survival of the affected species;
- the taking is to accommodate the needs of traditional subsistence users of such species; or
- extraordinary circumstances so require;

Marine turtles are listed in schedule 1 of Wildlife Conservation Laws in Ghana and are wholly protected.

Conventions and Regulations that Protect Marine Turtles in Ghana

Conventions.

The dwindling number of marine turtles has assumed a global phenomenon. Research and other relevant technical activities have underscored this global threat that is also acknowledge in Ghana. Turtles have therefore been listed in the International Union for the Conservation of Nature (IUCN) as either endangered or vulnerable. International conventions, treaties and memorandum of understanding (MOU's) of which Ghana is a signatory have further enhanced the conservation status of marine turtles. These include United Nations Convention on Migratory Species (CMS) and Convention on International Trade in Endangered species (CITES). It is incumbent on contracting parties to protect species in Appendix 1, which include all species threatened with extinction and may be affected by trade. The convention requires that a signatory member give the necessary protection to species listed in Appendix 1.

Regulations

The regulation has adequate provision for the protection of the species and its nesting habitat. In Ghana, all marine turtles are in the first scheduled of the wildlife conservation regulations L. I. 685 of 1971. (Wildlife Division, 2002). First schedule animals are completely protected (Appendix HI). This implies that the hunting, capturing or destroying of any species listed in this schedule is absolutely prohibited at all times. Marine turtles that nest on the coast of Ghana are listed in series B (iii) of the first schedule:

a. Hawksbill turtle (*Eretmochelys imbricata)*

b. Green or edible turtle (C*helonia mydas)*

c. Leathery turtle (*Dermochelys coriacea)*

Offences that contravene any of the regulations including the poaching of marine turtles are stated in Part I, II and III of the Wildlife regulations. Species of animals are also listed in the regulations according to schedules and series. (Appendix H2).

Part 7 of the Wetland management (Ramsar Sites) Regulations, 1999, L.I. 1659 list activities that adversely affect turtles and their nesting habitats and are restricted. The restricted activities stated in part 7 (c) include – ''No person shall within a Ramsar Site win sand, carry out quarrying activities or remove any soil except from areas approved by the Minister in writing''.

7 (d) ''No person shall hunt, capture, harm or deliberately disturb any wild animals including roosting, breeding and nesting birds, fledgling, turtles or their eggs except as provided for by the Minster'' (Wildlife Division, 1999). Other offences and associated penalties are stated in the regulation (Appendix H3).

CHAPTER THREE

MATERIALS AND METHODS

Description of the Study Areas

The study was conducted along the shoreline of two community reserves, Songor Ramsar Site and Keta Lagoon Complex Ramsar Site (Figure 1). The two sites are separated by the Volta river estuary and form an integral part of the lower Volta basin, characterized by sand beaches. The sandy beaches of the sites serve as critical habitat for a variety of wildlife species, including sea turtles. The aquatic ecosystems (the lagoon, river and the creeks) of the sites are highly influenced by the brackish water within the lower Volta basin. The sites have considerable nourished sandy beaches that receive adequate nesting turtles. The Songor Ramsar site is noted for traditional practices that protect nesting turtles (MAB, 2010). These practices, however, do not exist on the adjoining Keta Lagoon Complex Ramsar site, hence the need to undertake a comparative study on turtle nesting and conservation activities. The study sites were chosen based on their proximity to the work station of the Reserve to limit logistical and financial constraints.

Keta Lagoon Complex Ramsar Site (KLCRS)

Keta Lagoon Complex Ramsar Site (KLCRS) is situated within latitudes 5° 45'N - 6° 05'N and longitudes 0° 50'E - 1° 08'E and covers a total area of 127,780 hectares (Wildlife Division, 1999). It is bounded by Keta, Sogakope, Anloga, Akatsi North, and South Tongu Districts of the Volta Region. According to the 2021 Population and Housing Census the total population of the area was 319,412 with an annual population growth rate of

1.3% (GSS, 2021). The population density was 177 persons per square kilometer and a gender ratio of 1 male to 2 females (KEMA, 2022). The indigenes are Anlos in the south and Tongus and Avenors in the north. Fishing, salt wining and vegetable farming are the main occupations of the people in the south, while those in the northern sectors are mainly farmers with some fresh water fishing in the areas along the Volta river and creek channels (KEMA, 2022). The sandy beach on the southern portion of the area is an important nesting habitat for marine turtles. The beach over the years has been eroding faster than expected. However, groynes and revetments have been constructed to reduce erosion along some segments of the beach. Fort Prinzenstein, a national monument which is located within the site has lost portions of the fort building to sea erosion activities. The southern part is famous for its shallots and market gardening and produces large quantities of onion and okro. Other crops grown include pepper, tomatoes, cassava and maize (Wildlife Division, 1999). Lagoon fisheries are a major source of livelihood for many people in the area. Harvesting and commercial trade in mangrove trees for fuel wood is another important source of income in the area (KEMA, 2022).

The occurrence of waste material within the beach of the sampling area varied. Although, the waste materials were not very different, they were unevenly distributed. Plastics, rubbers and other waste materials occurred extensively and dominated the sampling area. Other waste materials, which included rags, abandoned nets and human excreta occurred throughout the sampling period. Human excreta were not very common along the shoreline in sampling site where the communities were normally located far from the beach. Regular clean-up activities that were undertaken along this section of the beach, probably might have contributed to the low occurrence of plastic and other waste within some sampling sites.

Portions of the beach was lighted during the night. Twenty - nine lights were observed along the beach of the sampling area, comprising 28 street and security lights and 1 domestic light. Security and streets lights were located 53 - 456m along streets and houses close to the beach. Only 1 domestic light was observed. The colour of the security and streetlights recorded were orange whilst the only domestic light recorded was white. The wattage of the security / street and domestic bulbs were 400 and 11 watts respectively.

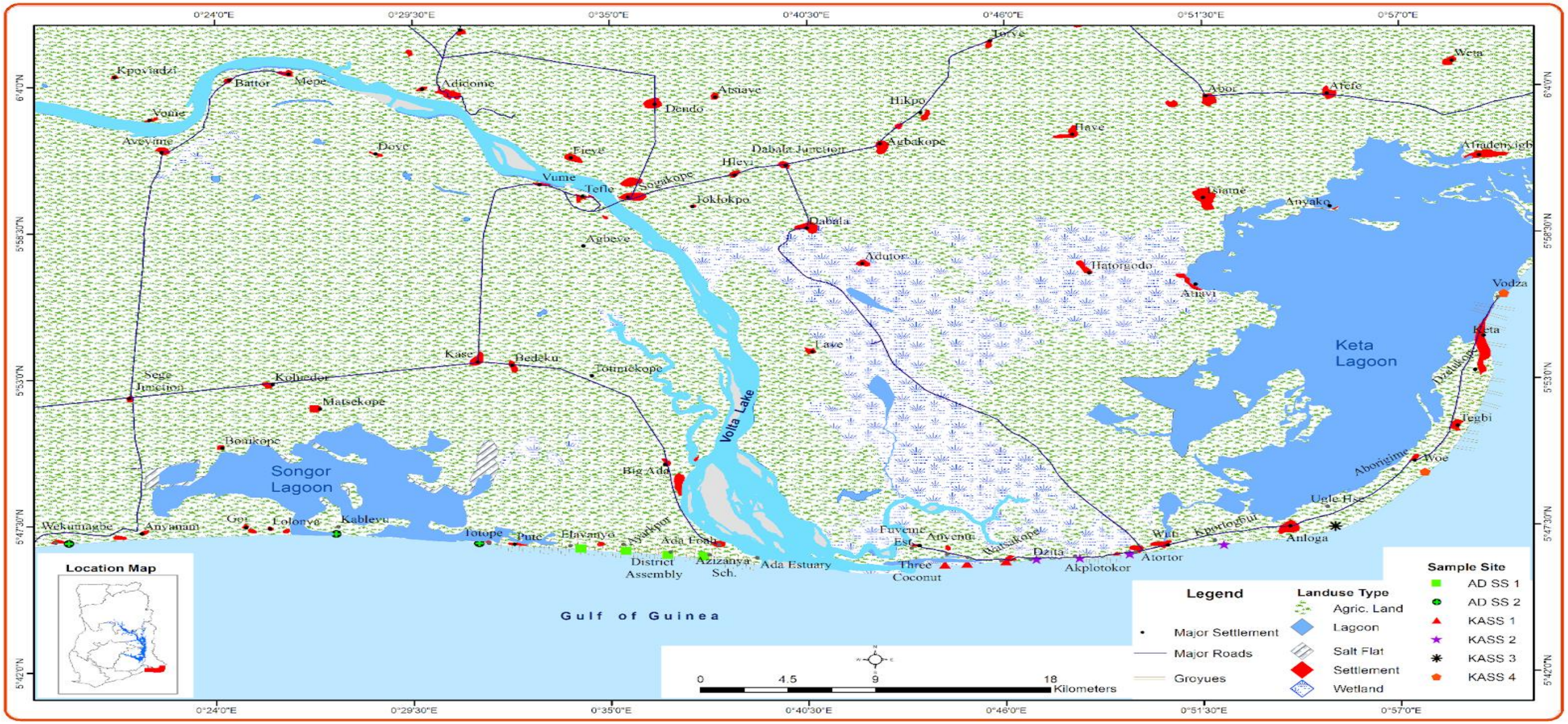

Figure 1: A map of the Volta Estuary showing the Songor and Keta Lagoon Ramsar sites (study sites)

Songor Ramsar Site (SRS)

Songor Ramsar Site (SRS), also a UNESCO Biosphere Reserve, has an area of 51,113.3 hectares and lies between latitudes 06.50N and 00°30E (Wildlife Division, 1999). The Songor Lagoon is closed off from the sea by a sand bar. The land around the lagoon is low-lying, with the highest point less than 10 m above sea level. The general elevation does not exceed 75 m above sea level in the northern part and 15 m above sea level near the coast. The open water covers an estimated area of 115 km^2 and extends about 20 km^2 along the coast and approximately 8 km inland behind a narrow sand dune (MAB, 2010).

Creek channels within the site supply brackish water to the eastern portion of the lagoon. Dwarf crocodiles, monitor lizards, African pythons, Gambian mongoose and other wildlife species occur in the area (MAB, 2010). The sandy beach that borders the southern portion of the reserve is an important nesting site for three of the globally endangered marine turtles. Although, erosion of the sandy beach is a major challenge, groynes have been constructed to reduce the rate of beach erosion. The estuary provides avenue for fish species to spawn intermittently to replenish their stock. Mammalian aquatic species like manatees, sharks and other big fishes occasionally migrate between these systems to feed. The estuary has made the site very popular as one of the preferred tourist destinations for water sports. The fresh water of the main Volta River is the spawning area for diverse species of fishes. Although, there is drastic reduction in species and stock levels due to over fishing and ecological changes, unsustainable fishing methods and other practices still persist. Dead fishes that float are mostly eaten by birds of prey such as the hawks (MAB, 2010). The islands are important terrestrial habitats of the Volta Delta system.

Some are occasionally isolated from human settlements. They habour diverse wildlife species including monkeys, crocodiles, water birds, African pythons, green and brown mamba, spitting cobra and birds of prey. The mangroves and other tree species that form grooves provide habitat for roosting, feeding and nesting birds. The continual encroachment on these islands has an implication for conservation of these species (MAB, 2016).

According to 2021 Population and Housing Census, Ada East District has a population of 76,411 people with females slightly outnumbering their male counterparts (GSS, 2021). The Ada West District was carved out of the former Dangbe East District in the Greater Accra Region. The District shares boundaries with North Tongu District to the North, Ada East District and Ningo Prampram to the East and West respectively. It is bounded to the South by the Gulf of Guinea, which stretches, from Akplabanya to Goi. It is approximately 80 Kilometers from Accra, the regional capital. The population of the district according to 2021 Population and Housing census, stands at 76,087 (AEDA, 2022). The Ada people are the descendants of the mixture of at least three district ethnic groups, namely; Dangmes, Akans or Ewes. Descendants of the Dangme groups are the people of Adibiawe, Lomobiawe, Tekperbiawe and Dangmebiawe. Those of the Akan groups are the Kabiawe-tsu, Kabiawe-yumu and Kabiawe-kpono and those of the Ewe groups are Kudjagbe, Korgbor and Ohuwem. The Dangmes were the nucleus to which the other two groups went and adhered themselves. With time all the groups became assimilated into what has now become the Ada culture. Although the cultures are the same traditional beliefs and taboos varies among the ethnic groups. Traditional beliefs and taboos thus vary among the ethnic clans and even families (Amate, 1999).

Human populations are clustered around the Songor lagoon, which provide significant food resources for the people. Consequently, human settlements are concentrated along the coast and around the northern edges of the lagoon. The present land use in the Songor area includes farming, animal rearing, fishing, salt collection, recreation, settlement and associated constructions such as roads. Farming, fishing and salt winning are the main occupation of the people. The Kodgragbe and the Dangme Biaweh clans own the land. About 30% of the lagoon area has been developed for salt production (AEDA, 2022). Thus, sea and fresh water entry at this section of the lagoon is managed by the salt industry. The Salt Industry Management pays royalties to the Tekpeh Biaweh clan that owns the lagoon (MAB, 2016). The main crops cultivated by inhabitants include cassava, maize and vegetables (particularly okra, pepper, and tomatoes). Small-scale livestock production is common in all the villages, with pigs being the most popular in the coastal villages, although small numbers of chicken, goats, ducks, and sheep are also kept. Cattle graze extensively on the grasslands in the north. Fishing is undertaken in both the lagoon and the sea, the latter being a major commercial activity, which extends into sacred areas. Bushes are burnt to hunt for small mammals and this encourages the regeneration of fresh grasses for livestock (MAB, 2016).

Waste that mainly occurred and dominated the beach of the sampling area were plastic materials rubber, rags, dead animals, food waste and human excreta. The dead animals observed included pigs, chicken, goat and sheep. Others that included rags and abandoned nets were very common and abound in the coastal communities. The sources of the waste were diverse. The plastics, rubbers and dead animals were observed to be deposited on the beach either by sea waves or floodwater from the communities. Dumpsites were located along the beach of some communities within the sampling area. These dump sites were another source of waste that litter the beach with plastics, rubber etc. Communities such as Lolonya, Goi, Anyamam, Akplagbanya and Wokumagbe located within this sampling site frequently dumped domestic waste along the beach. Occurrences of sea grasses on the beach were normally seasonal. It was mainly present in the months of June and October. Metals were mainly from abandoned ships and fishing trawlers, probably among the least observed within the samplings areas. Waste compromises the aesthetic beauty of sandy beaches and may interfere in turtle nesting processes.

Beach lighting had implication on turtle nesting on the beach. Two hundred and eighty-nine lights constituting 82 street and security and 207 domestic lights were located within the Ada sampling beach. Two hundred and seven were domestic lights representing 71.63% of sampled lights in Ada had wattage between 11 – 15 watts. The colours of the street and security lights were mostly orange and the wattage of the bulbs were 400 watts. Within the Ada sampling area security and streetlights were located at an average distance ranging between 97 - 498m depending on the proximity of the community to the beach. Domestic lights had diverse distances ranging between 42 - 345m from the beach.

Sampling and Data Collection

The study was conducted from April 2017 to March 2019 and data were collected at dawn during the last week of each month.

Sampling areas were classified into sampling sites based on the physical form of the shoreline as follows:

Songor Ramsar Site, which is on the western section of the Volta estuary was divided into 2 sampling sites and are described as follows:

- Sampling site 1, Ada Sampling Site 1 (Ad SS1): Located between the shoreline of Ada estuary and Pute and covers a distance of 16 km. Sea recession activities have been undertaken along this portion of the shoreline. Twenty two (22) groynes have been constructed to stabilize the beach.
- Sampling site 2, Ada Sampling Site 2 (Ad SS2): is a 24 km shoreline between Totope and Wokumagbe, the western boundary of the Songor Ramsar site. No beach recession and nourishment activities have been undertaken along the shoreline of this sampling site.

Six sampling points were randomly selected within sampling site 1 (Ad SS1) to monitor shoreline changes. The stations were selected using simple random method and they were unevenly spaced to limit biasness associated with the uneven distribution of the turtles. However, 3 sampling points were randomly selected within sampling site 2 (Ad SS2). It was observed that the shoreline characteristics did not vary within the selected sampling sites (Appendix 42).

Keta Lagoon complex Ramsar Site was classified into four (4) sampling sites based on numerous sea recession interventions within the shoreline.

- Sampling Site 1, Keta Anloga Sampling Site 1 (KA SS1): is on the immediate eastern portion of the Volta river estuary and close to a beach community, Fuveme. The sampling site ends at Dzita and it is approximately 14.05km from the Volta river estuary.

- Sampling Site 2, Keta Anloga Sampling Site 2 (KA SS2): covers a shoreline of 7.06km from Atorkor to Saviatula. The shoreline seems unstable and has undergone changes that were visible. Eleven groynes constructed from rock boulders have been used to stabilize the shoreline to protect the road and community properties at Apklortokor.
- Sampling site 3, Keta Anloga Sampling Site 3 (KA SS3): covers the shoreline between Srogbe and Anloga, with distance of 23.0 km. Over 70% of the shoreline within this site was observed to be very natural. It has therefore undergone intense erosion from wave action and was very unstable. The western end of this site was observed to be very stable.
- Sampling site 4, Keta Anloga Sampling Site 4 (KA SS4): was the terminal section of the sampling area and also the shortest segment of the sampling area. It covers a distance of 2.89km and was observed to have experienced intense erosive activities. The shoreline of this site is protected by 2 layers of horizontal groynes and revetments. Over 60% of the shoreline was nourished but the changes were observed to be highly erratic.

Eleven locations were randomly selected to monitor shoreline changes within the sampling area. Five locations were selected within sampling site 1 (KA SS1), 2 locations within sampling site 2 (KA SS2), 3 locations within sampling site 3 (KA SS3) and 1 location within sampling site 4 (Appendix 43).

Identification and Measurement of Morphometric Parameters of Turtles

Beach surveys were undertaken with an all-terrain vehicle (ATV). During the period of the survey, turtles encountered on the beaches were identified using FAO Sea turtle guide book (FAO, 2009). Features of crawling gaits of turtles were used to identify species that were not sighted on the shore. Nests, hatchlings and carapace of dead turtles encountered on the beach were examined to identify the species.

Morphometric parameters which include total turtle length (TTL), straight carapace length (SCL), curved carapace length (CCL), straight carapace width (SCW) and curved carapace width (CCW) of nesting or stranded turtles were measured using measuring tape to establish difference between species and sexes. In the case of nesting turtles, the length of the hind flippers were also measured to establish the ratio of flipper length to nest depth.

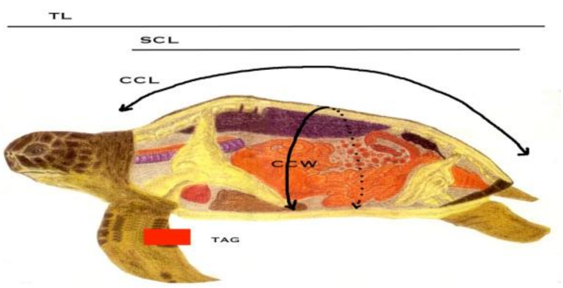

Figure 2: Turtle morphometric parameters that were measured during the survey.

Physical deformities and presence of tumors, epizoites and tags were noted. Data on turtles that reappear to nest on the beach (inter nesting periods) were established by appropriately marking nesting turtles with green paint. However, yellow paints were used to mark non-nesting, stranded or disoriented individual turtles to distinguish them from turtles that reappear to nest on the beach.

Determination of Turtle Population Parameters

Enumeration of stranding and nesting turtles

Stranding and nesting turtles were counted while traversing the beaches on an ATV. Coordinates of nests locations were recorded with GPS. The trend of nesting population was estimated by counting the nest produced each season by the females. The assumption is that a) the number of nests laid per female will be constant over time and b) the nesting cycle remains the same. The relative abundance of species were estimated; Relative Abundance (%) = Isi/∑Nsi X 100.

Where, Isi = Total Number of individual species

∑ Nsi = Total Number of species population.

Identification and enumeration of crawling gaits

Crawling gaits are typical symmetrical or asymmetrical track patterns of turtles on the shore. They are created by turtles that emerge from sea to the beach and provides vital information for the identification of species that were not seen on the beach (Campbell et al., 2012). Crawls observed were indicated as true or false crawls with the former leading to species nest. To avoid double counts, crawling gaits were defaced by appropriately moving the wheels of the ATV repeatedly on the identified crawls. Environmental information of the crawl sites were recorded e.g. the existing vegetation, beach pollutants and the physical nature of the beach. The height of sand dunes on the shore were established with measuring tape.

Identification and enumeration of turtle nests

The beach was traversed in the night with ATV (All-Terrain vehicle) and the beach sand was closely observed for any turtle nest and other nesting activities. After successful location of turtle nests, the following information were determined; date and time the nest was sighted, the location, GPS coordinates, species, nest depth, nest distance from mean tidal mark, clutch size per nest and nature of beach. Beach surveys were conducted at night and dawn to record nests that were created by turtles. Nest depth was determined with a meter rule. To improve the precision for determining beach preference the sampling area was divided into sites. Nest density was calculated using the equation: Nest density = No. of nests / beach area. During the survey, underlying substrate of turtle nests located on the shore were established through the insertion of calibrated rule. Granulometric data on turtle nest were established through laboratory techniques (George. et al. 2016). Sand samples were collected randomly along the shore and around turtle nests. The sand samples were collected at 40cm depths and were weighed, dried and shaken with screens with diverse mesh sizes.

Estimation of hatching success

The ratio of hatchlings to eggs deposited in the nest provide information on the estimation on hatching success and the probable suitability of the nesting sites. Information on hatchlings were obtained when sighted; the date and time, location, identification of species, number of hatchlings and empty shells. Hatching success (Hs) was estimated in percentage (%).

Identification of Threats

Predation of eggs

Monthly data on possible predators of turtle nests were obtained by direct counting of predators sighted on the beach during the survey. The number of particular predators frequently sighted on the beach, preference for species nest, successful and unsuccessful predatory attempts were determined.

Poaching of turtles

The number and species of nesting and stranding turtles poached in some beach communities were recorded based on crawling gaits. Poached turtles are likened to incomplete crawling gaits relative to one-way movement on the shore. Unpoached turtles are likened to having completed a two-way crawl movement from the sea to the shore and vice-versa. Other data such as date and time of poaching, species and number poached, preferred species poached, areas of high incidence of poaching and poaching method used were all established. Frequency of poaching (number of turtle poached / relative to the sampling months) was also determined for sampling areas and sites.

Estimation of turtle deaths

The number of dead turtles on the shore were determined through counts, whiles the species was ascertained by identification of whole or remnant parts. Dead turtles were examined externally to establish the cause of death, whether natural, accidental or human induced. Coordinates of position of dead turtles were determined using GPS. The mortality rate was ascertained by determining the ratio of the number of deaths to the average total population during the sampling period. $tm = \frac{\text{number of dead individuals}}{\text{Total living population}}$ x 100%, where tm is turtle species mortality.

Determination of sex of dead turtles

Sex of dead turtles were determined to ascertained the variations amongst the species. The number of dead turtles and species occurrence was compared between sampling areas and sites. To avoid double count, carapace or appropriate parts of dead turtles were marked with red paint indicating the month and year turtles were recorded.

Measurement of Environmental Parameters

Beach sand granulometry

Sand granulometry that influences hatching of turtle eggs were determined through analysis of natural and nourished sand by appropriate laboratory techniques (George. et al. 2016). Particle sizes of preserved soil specimen were determined using laboratory sieve of diverse mesh sizes (0.5µm, 0.05µm and 0.005µm) in the Ada Senior High Science Resource Centre. Sieved soil particles were categorized by the size of mesh they were trapped in. Grains of size 0.005µm, 0.05µm and 0.5µm were categorized as fine, medium coarse and large coarse textures respectively.

Estimation of changes along the shoreline

Beach morphodynamics was determined using Garmin GPS to determine movement along shoreline. Coordinates of selected base points were taken to the dune or highest tidal point on the shore. The displacement between successive months were determine using a ruler tool on Garmin GPS to undertake measurement on the shapefile. The cross - shore distance at each point indicate the extent of erosion and accretion across the sampling periods. Dune heights were measured using calibrated rule and, in some cases, measuring tape. Probable impact of changes on the shore on nesting turtles were physically observed. Thematic map and images of specified intervals covering the study area were obtained from geological survey website for analysis. The subsequent map produced using GIS software will indicate the rate and extent of changes that have occurred over time.

Lighting of beach

This was to determine the physiological responses of species to shore illumination and compared to dark environments. At each beach, the location of lights, number of lights, information on type of light (color and wattage) and purpose of installation of lights (street light, domestic etc.), orientation and elevation of light were documented. The number of turtle species that utilized illuminated and dark beaches was recorded.

Moon phase and moon light

The influence of natural light; moon light and moon phases on nesting, stranding and turtle hatchlings was evaluated. The moon phase of survey period was noted whiles the number of turtles, species sighted, number of new nests, number of hatchlings, orientation of nesting species and hatchlings was documented. Information on moon phase was obtained from Ghana Ports and Habour Authority tidal chart and from goggle website.

Data Analysis

Microsoft Office (Excel spreadsheet) was used to compute and analyse biophysical and species data obtained from the field survey. Descriptive statistics was used to interpret results obtained. To interpret the trends in the data, frequency distribution, mean and standard deviation were used. Graphs and appropriate tables were developed using Microsoft Office (Excel). The mean of turtle nest and beach erosion of sampling areas, sampling sites and sampling periods were compared using t-test. Analysis of Variance (ANOVA) was used for the comparison of means of turtle nest, nest crawls, non-nest crawls and beach erosion and beach accretion. Correlation analysis was used to determine the extent of relation between turtle nest, nest crawls, non-nest crawls, beach erosion and accretion, between sampling sites and species recorded.

CHAPTER FOUR

RESULTS

Turtle Species Composition at the Songor Ramsar Site (SRS)

Four species of marine turtles were encountered during the sampling period (April 2017 to March 2019) within the Songor Ramsar Site (Figure 3 and Appendix 1). These turtle species comprised Olive ridley turtle *(Lepidochelys olivacea)*, Leatherback turtle (*Dermochelys coriacea*), Green turtle (*Chelonia mydas*) and Hawksbill turtle (*Erectmochelys imbricata). D. coriacea* was most abundant species with relative abundance (RA%) of 62.13% whiles *L olivacea* was 37.33%. The least abundant recorded species was the *E. imbricata* (Appendix 3).

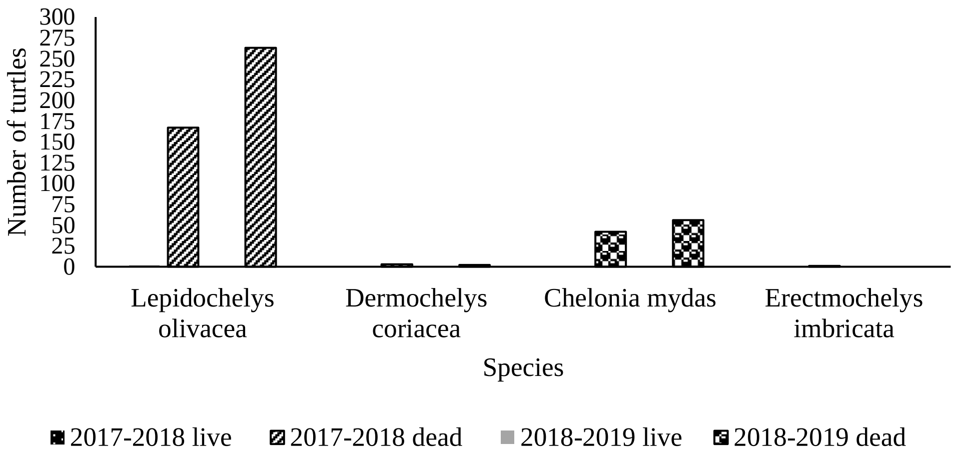

Figure 3: Number of the different species of turtles identified at the Songor Ramsar Site (2017 – 2019)

Turtle Species Composition at the Keta Lagoon Complex Ramsar Sites (KLCRS)

Species of turtles that were recorded during the sampling period (April 2017 – March 2019) within the Keta Lagoon Complex Ramsar Site (KLCRS) are shown in (Figure 4 and Appendix 3). Three species, *L. olivacea*, *D. coriacea*, *C. mydas*, occurred within the Keta Lagoon Complex Ramsar Site (KLCRS) sampling area. *D. coriacea* was the most frequently encountered species, with nests, carcasses and carapaces They were the most abundant turtle species recorded with a relative abundance of (RA%) 77.20%. The relative abundance of *L. olivacea* was 22.78%.

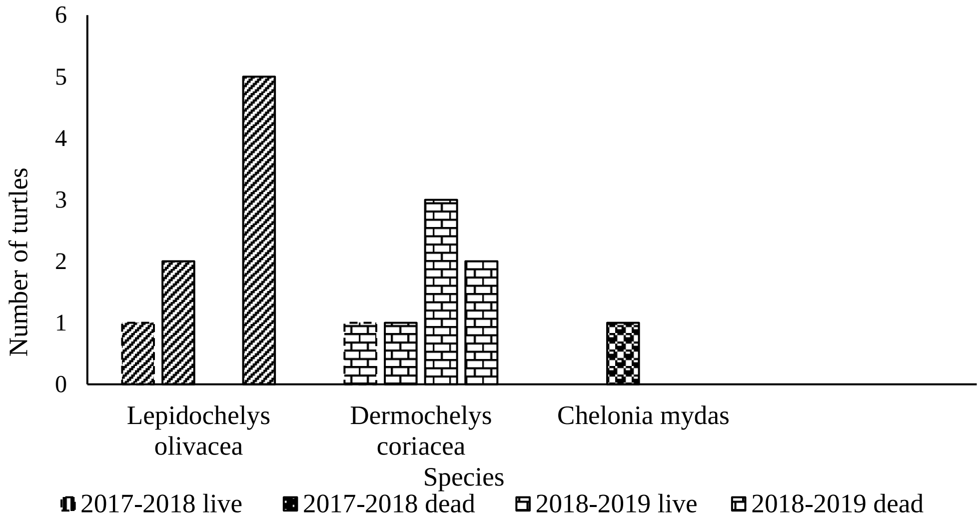

Figure 4: Number of the different species of turtles identified at the Keta Lagoon Complex Ramsar Site (2017 – 2019)

Occurrence of Nesting and Stranding Turtles at the Songor Ramsar Site

Three nesting turtles were recorded, comprising an *L. olivace)* and 2 *D. coriacea* turtles (Table 1). *Lepidochelys olivacea* were recorded in September 2017 and within sampling site 1. Two *D. coriacea* turtles were each encountered in December 2018 within sampling site 1 and 2. However, no stranding turtles were recorded during the sampling periods within the Songor Ramsar sampling area.

Table 1: Total stranding and nesting turtles (2017 – 2019)

Year		**Species**		
	Lepidochelys olivacea	*Chelonia mydas*	*Dermochelys coriacea*	*Erectmochelys imbricata*
2017/2018				
Nesting	1	-	-	-
Stranding	-	-	-	-
2018/2019				
Nesting	-	-	2	-
Stranding	-	-	-	-
Totals	**1**	**-**	**2**	**-**

Occurrence of Nesting and Stranding Turtles at the Keta Lagoon Complex Ramsar Sites

Four nesting *D. coriacea* turtles and 2 stranding turtles comprising 1 *L. olivacea* and 1 *D. coriacea* were encountered (Table 2). Nesting *D. coriacea* occurred in November 2017, whiles the stranding *D. coriacea* turtle was recorded in January 2017. Both turtles were recorded within sampling site 1 (Appendix 3). The stranding *L. olivacea* was recorded in November 2018. Three nesting *D. coriacea* were encountered in October 2018 and December 2018. The nesting *D. coriacea* were evenly distributed within three sampling sites 1, 2 and 3 (Table 2). No stranding turtles were recorded during the 2018 - 2019 sampling period.

Table 2: Total stranding and nesting turtles (2017 - 2019)

Year		**Species**	
	Lepidochelys olivacea	*Chelonia mydas*	*Dermochelys coriacea*
2017/2018			
Nesting	-	-	1
Stranding	1	-	1
2018/2019			
Nesting	-	-	3
Stranding	-	-	-
Totals	**1**	**-**	**5**

Morphometric Data of Stranding and Nesting Turtles at the Songor Ramsar Site

Morphometric data of 9 turtles were recorded during the sampling period comprising 2 *L. olivacea* and 7 *D. coriacea*. The mean total length (TL) of *L. olivacea* turtles recorded were 73.95cm, straight carapace length (SCL) was 67.7cm, curved carapace length (CCL) was 70.2cm, straight carapace width (SCW) 64.9cm and curve carapace width (CCW) 66.8cm. The mean measurements of Leatherbacks recorded within the 2 sampling areas showed some level of variations. Within the Songor Ramsar sampling area the mean total length (TL) of *D. coriacea* was 160.7cm, (SD = 7.1), straight carapace length (SCL) was 146.6cm, (SD =7.2), curved carapace length (CCL) was 156.75cm, (SD = 8.9), straight carapace width (SCW) 115.3cm (SD = 3) and curve carapace width (CCW) 130.5cm. (SD = 2.1). The minimum total length (TL min) of *D. coriacea* was 153.6cm whiles the maximum total length (TL max) was 167.8cm. The minimum straight carapace length (SCL min) was 147.8cm whiles the maximum was 165.7cm. The minimum curved carapace length (CCL min) was 112.3cm whiles the maximum was 118.3cm. The minimum straight carapace width (SCW min) was 128.4cm and the maximum curve carapace width (CCW max) 132.6cm.

Morphometric Data of Stranding and Nesting Turtles at the Keta Lagoon Complex Ramsar Site

Within the Keta Lagoon Complex sampling area, the mean total length (TL) of *D. coriacea* turtle was 157.6cm, (SD = 4.7), straight carapace length (SCL) was 149.54cm, (SD = 5.4), curved carapace length (CCL) was 153.64cm, (SD = 5.8), straight carapace width (SCW) 138.8cm, (SD = 10.2) and curve carapace width (CCW) 143.74cm, (SD = 6.6). Within the sampling area the minimum total length (TL min) of *D. coriacea* was 149.2cm whiles the maximum total length (TL max) was 163.5cm. The minimum straight carapace length (SCL min) was 138.9cm whiles the maximum was 154.3cm. The minimum curved carapace length (CCL min) was 142.3cm whiles the maximum was 157.8cm. The minimum straight carapace width (SCW min) was 133.5cm and the maximum curve carapace width (CCW max) 153.84cm.

Distribution of Turtle Nesting Activities at the Songor Ramsar Site

A total of 1,397 turtle activities were encountered within the sampling area, comprising 810 *L. olivacea*, 108 *C. mydas*, 478 *D. coriacea* and 1 *E. imbricata* (Figure 5 and Appendix 2).

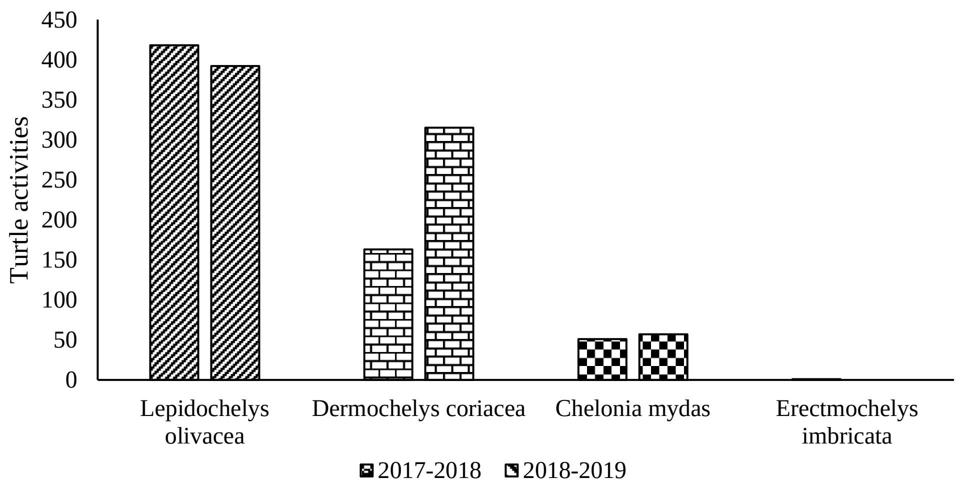

Figure 5: Total turtle activities observed, 2017 – 2019 at the Songor Ramsar site

Distribution of Turtle Nesting Activities at the Keta Lagoon Complex Ramsar sites

A total of 632 turtle activities comprising 190 *L. olivace),* 1 *C. mydas* and 441 *D. coriacea* were recorded from April 2017 – March 2019 (Figure 6 and Appendix 3). There was 31.96% increase in turtle nesting activities in 2018 - 2019 compared to 2017 - 2018 sampling period.

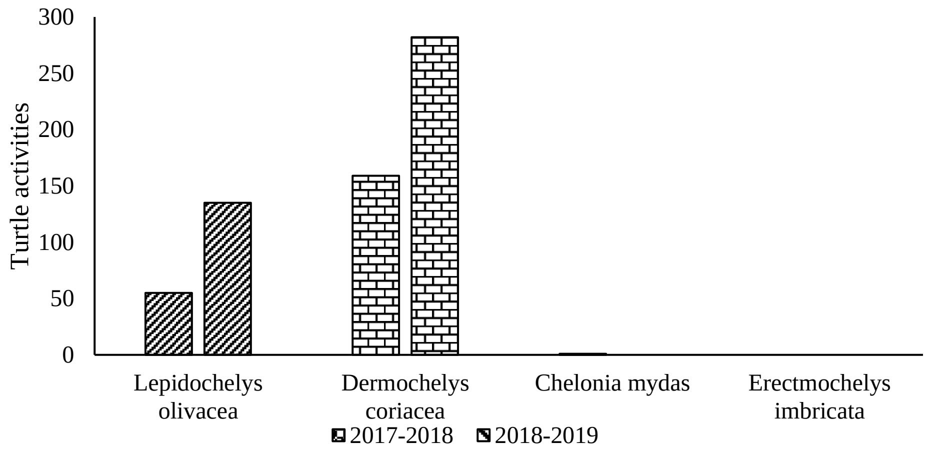

Figure 6: Total turtle activities observed, 2017 – 2019 at the Keta Ramsar site

Lepidochelys olivacea activities were encountered throughout the sampling periods. Their activities were however commonly encountered between the months of June 2017 and September 2017 during 2017 - 2018 sampling period, whiles in 2018 - 2019 period, the activities were concentrated between August 2018 and October 2018 (*Figure 7*). *Chelonia mydas* species activities occurred between September 2017 and December 2017 during 2017 - 2018 and February 2018 during 2018 - 2019. It was observed that the nesting activities of *D. coriacea* were asynchronous to *L. olivacea*. During 2017 - 2018, the activities occurred between the months of November 2017 and February 2018 and in 2018 - 2019 they were encountered in November 2018 and January

2019 (Figure 7). Only one *E. imbricata* activity was encountered during the sampling period within Songor Ramsar sampling area in December 2017. The activities of the turtle species were unevenly distributed within the sampling areas.

Figure 8: Olive ridley turtle nesting on the beach

Figure 9: Leatherback turtle crawling

Turtle Deaths recorded at the Songor Ramsar Site

During the sampling period 534 dead turtles were encountered representing 97.98% of total dead turtles recorded. These comprised of 430 *L. olivacea* (78.89%), 98 *C. myda* (17.98%), 5 *D. coriacea* (0.91%) and a *E. imbricata* turtle (0.18%). The number of dead turtles recorded varied within the sampling periods and sampling sites as presented in figure 9 and 10. However, there was significant difference in the mean of the species recorded during 2017 – 2018 (p = .023) (Appendix 49). During the 2017 - 2018 sampling period, a total of 213 turtle deaths were recorded. One hundred and sixty-seven dead *L. olivacea* were recorded, of which 25 occurred in sampling site 1 and 142 in sampling site 2 respectively. Forty-two dead *C. mydas* were recorded within the same period of which 13 were encountered in sampling site 1 and 29 in sampling site 2. Three dead *D. coriacea* were recorded, of which 2 occurred in sampling site 2 whiles one was recorded in sampling site 1. The only dead *E. imbricata* was recorded in sampling site 2.

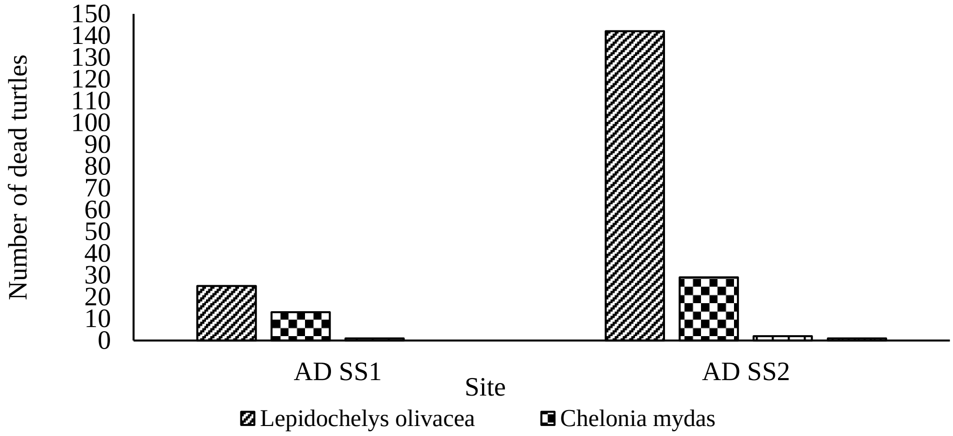

Figure 10: Occurrence of dead turtles and sampling sites (2017 – 2018) at Songor Ramsar site

During the 2018 - 2019 sampling period, 321 turtle deaths were encountered of which 263 were *L. olivacea* (Figure 10*)*. Out of these, 36 *L. olivacea* deaths occurred within sampling site 1 whiles 227 was recorded in sampling site 2. Fifty- six *C. mydas* deaths occurred of which 7 and 49 were encountered in sampling site 1 (Ad SS1) and 2 (Ad SS2) respectively. Two *D. coriacea* deaths occurred only in sampling site 2 (Ad SS2)

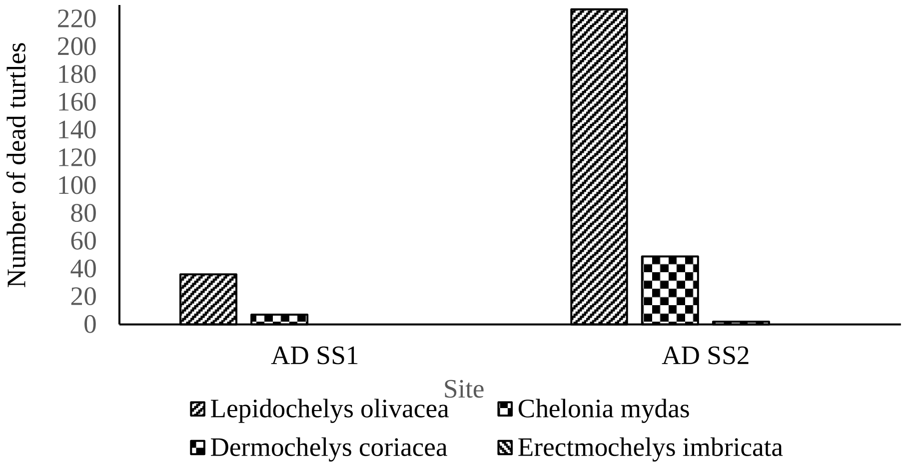

Figure 11: Occurrence of dead turtles and sampling sites (2018 – 2019) at different sites of Keta Lagoon Ramsar Site

Figure 12: A dead Olive ridley turtle found at Songor Ramsar site (marked to avoid double count)

Variations in turtle deaths were observed within the sampling periods (Figure 12). In 2017 - 2018 high turtle deaths were recorded between the months of September and November. Turtle deaths recorded were moderately low between the months of April 2017, August 2017, December 2017 and March

2018 (Figure 12). During 2018 - 2019, turtle deaths recorded were high between the months of August 2018 and September 2018. There was a dip in turtle deaths recorded between the months of April 2018 and July 2018 and October 2019 to March 2019 (Figure 12).

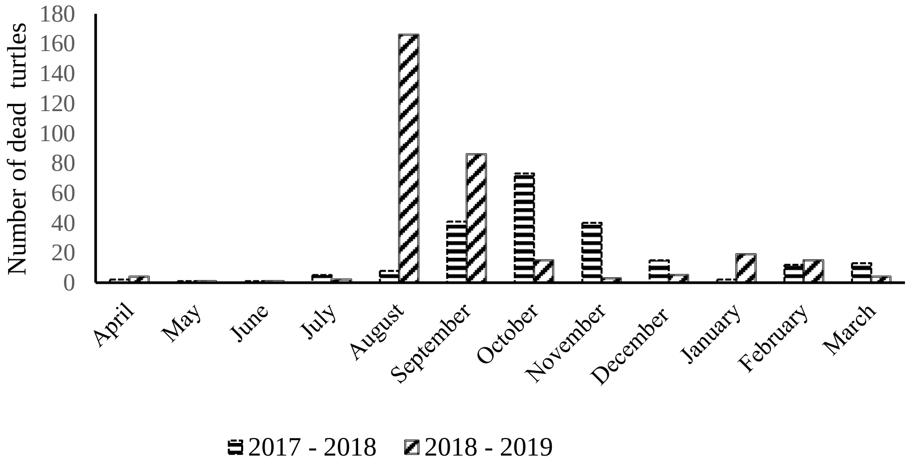

Figure 13: Seasonal distribution of turtle deaths observed, 2017 – 2019 at Songor Ramsar site

Turtle Deaths recorded at the Keta Lagoon Complex Ramsar sites

Eleven turtle deaths were recorded during the sampling period, representing 2.01% of the total turtle deaths. These comprised of 7 *L. olivacea* turtles, 1 *C. mydas* and 3 *D. coriacea* turtles (Appendix 1).

A total of 4 turtle deaths were recorded during 2017 - 2018 sampling period. These comprised of 2 *L. olivacea* turtles which were recorded in sampling site 2, *C. mydas* in sampling site 3 and *D. coriacea* sampled in site 2 (Figure 12).

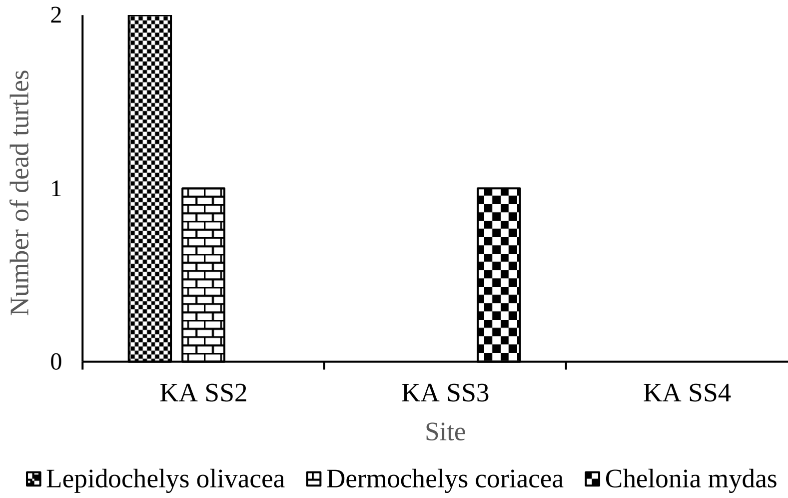

Figure 14: Occurrence of dead turtles (2017 – 2018) at different sites of Keta Lagoon Ramsar site

During the 2018 - 2019 sampling period, seven 7 turtle deaths, comprising 5 *L. olivacea* and 2 *D. coriacea* deaths were encountered. Three *L. olivacea* turtle occurred in sampling site 1, whiles 2 were recorded in sampling site 3. During the same sampling period, *D. coriacea* was each recorded in sampling site 1 and 3 (Figure 14).

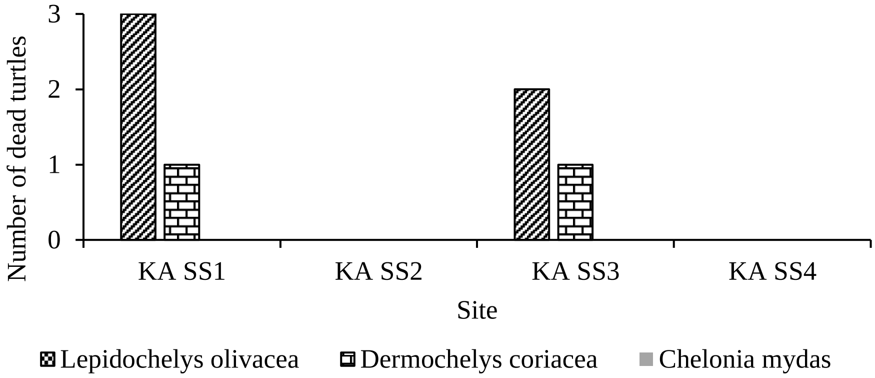

Figure 15: Occurrence of dead turtles (2018 – 2019) at different sites of Keta Lagoon Ramsar site

Four dead turtles, one each was encountered within the month of September to December 2017 (Figure 15). A staggering pattern was however displayed in 2018 - 2019 sampling period. A total of 7 deaths were recorded of which 1 each occurred in May 2018 and July 2018, 3 in January 2019 and also 2 in February 2019 (Figure 15).

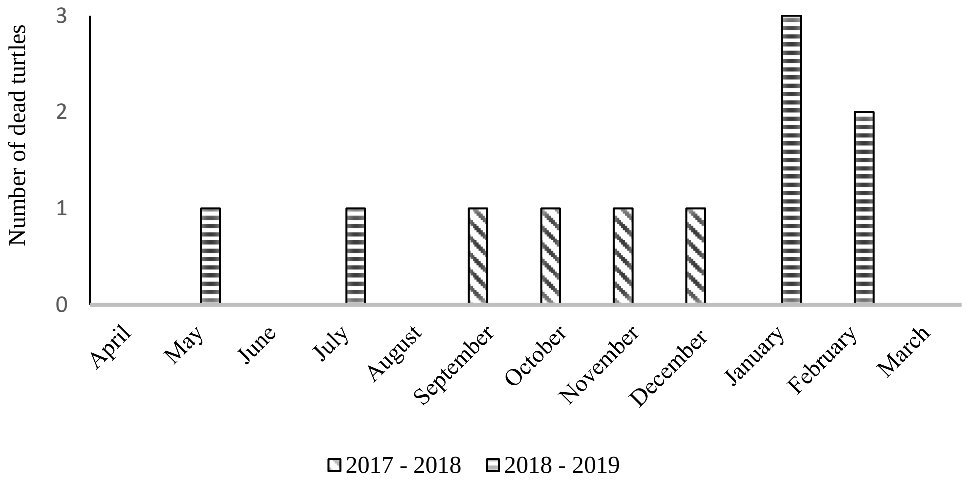

Figure 16: Seasonal distribution of turtle deaths, 2017 – 2019 at Keta Ramsar site

Turtle Mortality recorded at the Songor Ramsar Site

The mortality rate of the sampling area was 0.92 deaths per the sampling period or 92.3%. During 2017 – 2018, mortality rate for *L. olivacea* was 0.28 deaths / year or 28.3%, indicating the species with the highest mortality rate. The mortality rate estimated for *C. mydas* was 0.07 deaths / year or 7.3%, *D. coriacea* was 0.01 deaths / year or 0.5% and *E. imbricata* was 0.001 deaths / year or 0.2%. Within 2018 – 2019 period mortality rates of *L. olivacea* and *C. mydas* increased by 22.3% and 18.3% respectively. The rate for *L. olivacea* was

0.46 deaths / year or 45.5% whilst the rate for *C. mydas* was 0.09 deaths / year or 9.7%. The rate for *D. coriacea* dropped to 0.003 deaths / year or 0.35%.

Turtle Mortality at Keta Lagoon Complex Ramsar Site

The mortality rate of the sampling area was 0.02 deaths per sampling period or 1.9%. A rate of 0.003 deaths / per year or 0.34% was derived for *L. olivacea*, 0.001deaths / year or 0.2% for *C. mydas* and *D. coriacea* respectively in 2017 -2018. Mortality rate increased marginally in 2018 – 2019. Mortality rate for *L. olivacea* was 0.008 deaths / year or 0.86% whilst a rate of 0.003 deaths / year or 0.35% was recorded for the *D. coriacea.*

Sex Ratio of Dead Turtle Species at the Songor Ramsar Site

The sexes of the 534 dead turtles encountered were determined and these comprised of 112 males constituting (20.97%) of the dead turtles, 326 females (61.05%) and 96 indeterminate (17.97%).

During the 2017 - 2018 sampling period, the sex of 213 dead turtle species were determined. These comprised of 167 *L. olivacea* turtles of which 30 were males, 98 were females and 39 indeterminate. Forty-two *C. mydas* of which 8 males, 26 females and 8 indeterminate turtles were encountered. Five *D. coriacea* turtles were determined of which all were indeterminate (Figure 16)

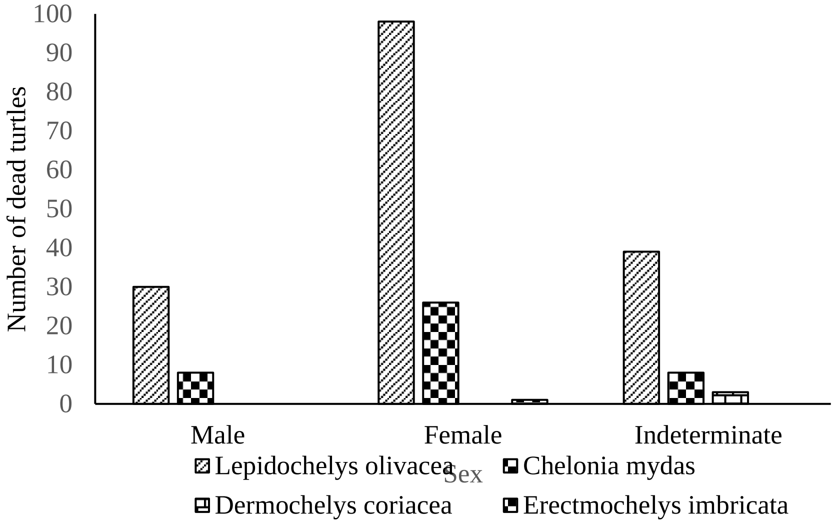

Figure 17: Sex of dead turtles (2017 – 2018) found at the Songor Ramsar Site

Within the 2018 - 2019 sampling period, the sex of 321 dead turtles were determined. Of these, 46 males, 181 females and 36 indeterminate turtles recorded were *L. olivacea* turtles. Out of 56 *C. mydas* turtles encountered 28 males, 19 females and 9 indeterminate turtles were recorded. Two (2) *D. coriacea* turtles were also encountered of which 1 female and 1 indeterminate turtles were encountered (Figure 17).

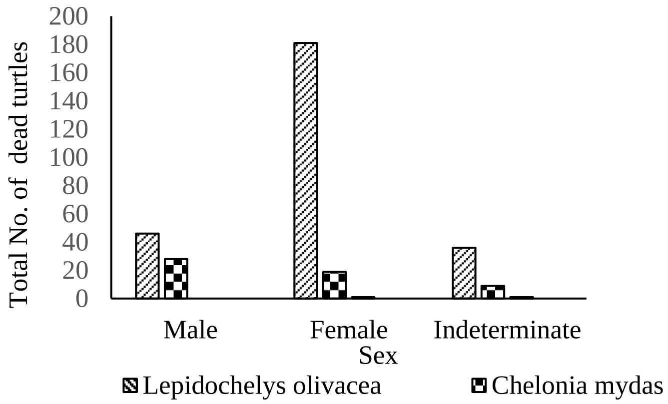

Figure 18: Sex of dead turtles (2018 – 2019) found at the Songor Ramsar Site

Difference in sex of dead turtles sampled occurred annually as indicated in Figures 18 and 19). In 2017 - 2018 sampling period. Dead female turtles dominated with 125 females recorded during the period. The concentrations of the dead female turtles were within the months of August 2017 and December 2017, peaking in October 2017 (54) (Figure 18). During 2018 - 2019 sampling period, 201 dead female turtles were recorded, the concentration was between August 2018 and October 2018 and also January 2019. The highest activities were recorded in August 2018 (124) (Figure 19). The sex of male dead turtles determined varied between the two sampling periods. Thirty-eight dead male turtles were recorded during 2017 - 2018 period whiles 74 were recorded in 2018 - 2019. During the 2017 - 2018 sampling period the activities were concentrated between the months of September 2017 and November 2017, whiles in 2018 - 2019, it was in the months of August 2018, September 2018 and February 2019. Fifty indeterminate dead turtles were recorded in 2017 - 2018 and the concentration period was between the months of September 2018 and November 2018. In 2018 - 2019 sampling period, 46 indeterminate dead turtles encountered were concentrated between the months of August 2018 and September 2018 (Figure 19).

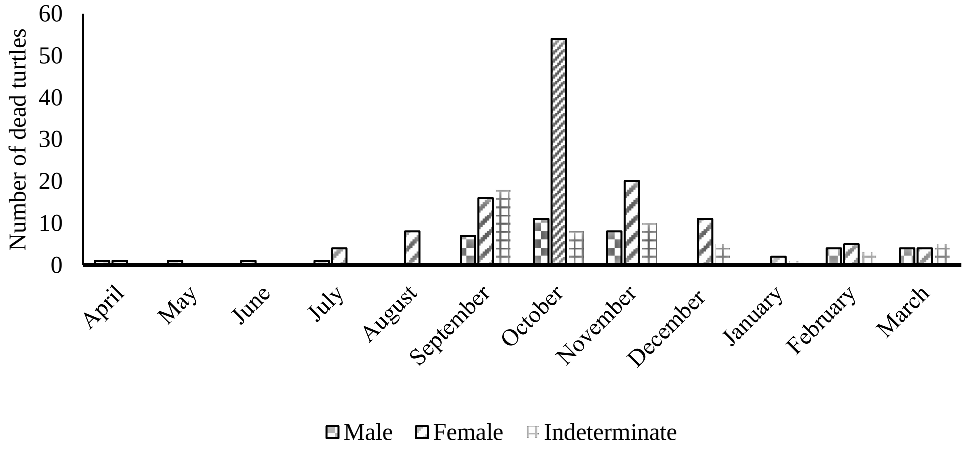

Figure 19: Seasonal distribution of sex of dead turtles at Songor Ramsar site, 2017 - 2018

Figure 20: Seasonal distribution of sex of dead turtles at Songor Ramsar site, 2018 – 2019

Sex Ratio of Dead Turtle Species at the Keta Lagoon Complex Ramsar Sites

Within the sampling area, the sex of 11 dead turtles were determined, comprising 1 (9.09%) male dead turtle, 4 (36.36%) females and 6 (54.54%) indeterminate. The sex of the only dead male turtle was a Green turtle (*C.*

mydas), whiles the 4 female dead turtles composed of 3 Olive ridley (*L. olivacea*) and a *D. coriacea* turtles. Three *L. olivacea*, a *C. mydas* and 2 *D. coriacea* turtles constituted 6 indeterminate dead turtles.

The sex of 4 dead turtles were determined within 2017 - 2018 period (Figure 20). This comprised of 2 *L. olivacea* turtles of which 1 was a females whiles 1 was indeterminate. The sex of 1 *C. mydas* and 1 *D. coriacea* turtles constituted 2 indeterminate dead turtles.

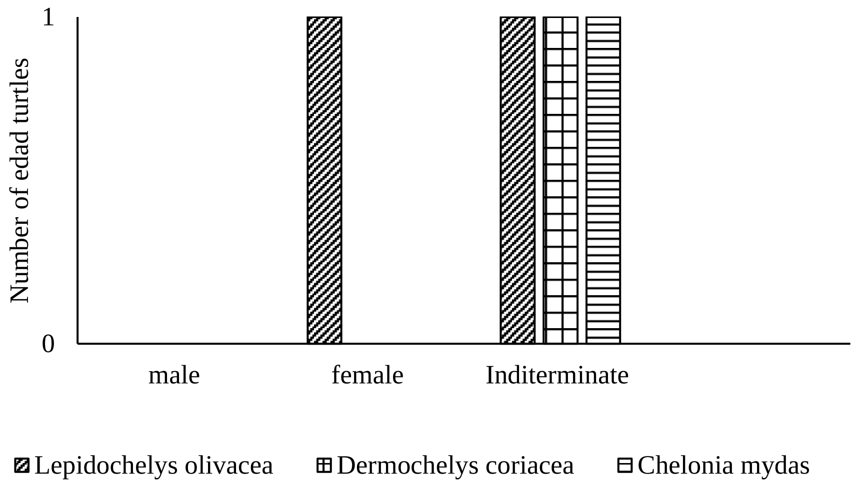

Figure 21: Sex of dead turtles observed at the Keta Lagoon Ramsar site, (2017 – 2018)

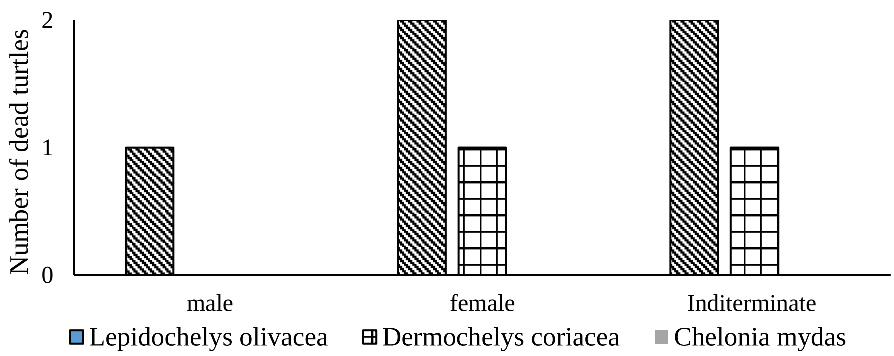

Figure 22: Sex of dead turtles observed *at* the Keta Lagoon Ramsar site, (2018 – 2019)

During 2018 – 2019 period the sex of 7 dead turtles were determined (Figure 21). This comprised of five *L. olivacea* turtles of which 1 male, 2 females and 2 indeterminate sex were determined. Two *D. coriacea* turtles of which 1 female and 1 indeterminate were determined.

The variations within the sampling periods did not depict any regular pattern as shown in Figures 22 and 23. In 2017 - 2018 sampling period no male dead turtle was recorded (Figure 22), whiles in 2018 - 2019 period the sex of only one male dead turtle was recorded in July 2017. A female dead turtle was recorded in October 2017. One dead female turtles was recorded in May 2018, January 2019 and February 2019 during the 2018 -2019 sampling period (Figure 23). Three indeterminate dead turtles were encountered in the months of September 2017, November 2017 and December 2017 during 2017 - 2018 periods. In 2018 - 2019 period, 3 indeterminate dead turtles were encountered, 2 in January 2019 and 1 in February 2019 (Figure 23).

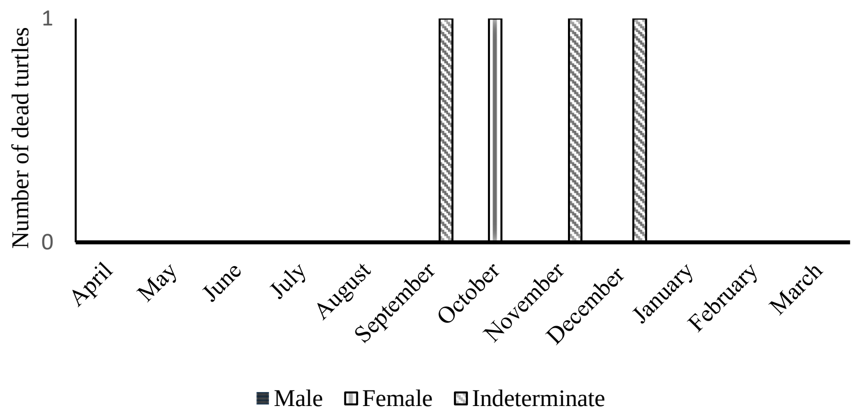

Figure 23: Seasonal distribution of turtle deaths observed *at* Keta Lagoon Ramsar site, 2017 - 2018

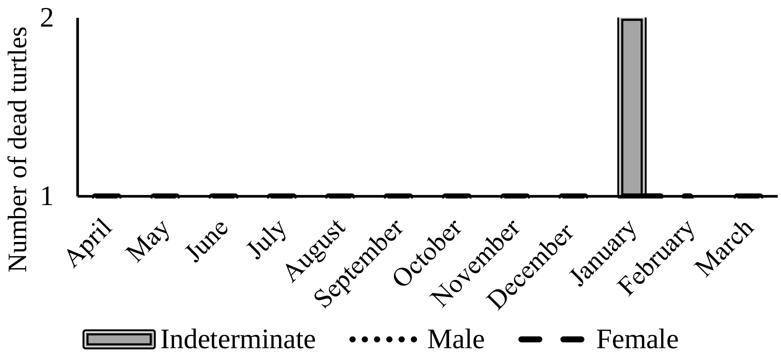

Figure 24: seasonal distribution of turtle deaths observed at Keta Lagoon Ramsar site, 2018 – 2019

Spatial Distribution of Turtle Crawls and Nests at the Songor Ramsar Site

A total of 714 turtle crawls and nest were recorded comprising 251 *L. olivacea* crawls and nests (35.2%), 10 *C. mydas* turtles (1.40%) and 453 *D. coriacea* (63.5%). Total turtle crawls and nest were observed to vary between the species within the sampling area.

Total turtle crawls and nest recorded varied within sampling sites. Within 2017- 2018 periods, 91 *L. olivacea* crawls and nests were encountered in sampling site 1 and 88 were in sampling site 2 (Figure 24). During the same period, 74 *D. coriacea* crawls and nests were recorded in sampling site 1, whilst 75 were recorded in sampling site 2. Nine (9) *C. mydas* crawls and nests were recorded in sampling site 2.

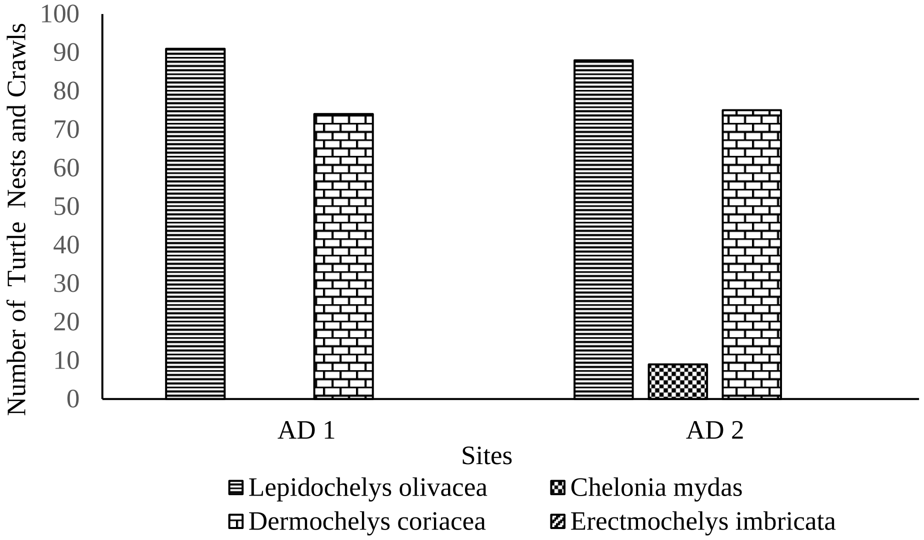

Figure 25: Number of nest and crawls at different sites, 2017 – 2018 at Songor Ramsar site

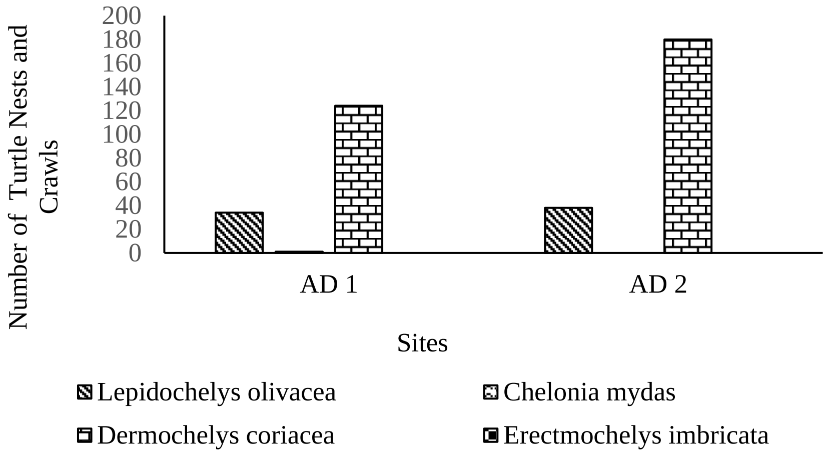

Figure 26: Number of nests and crawls at different sites, 2018 – 2019 at Songor Ramsar site

During 2018 - 2019 sampling period, 34 *L. olivacea* crawls and nests were recorded in sampling site 1, whilst 38 were in sampling site 2. Only 1 *C. mydas* non-nesting crawl was recorded in sampling site 1. Three hundred and four *D. coriacea* crawls and nests were recorded during the sampling period, with 124 occurring in sampling site 1 and 180 in sampling site 2 (Figure 25).

Seasonal variations of nest and crawls occurred during the nesting season. During 2017 -2018 sampling period 179 *L. olivacea* crawls and nests were recorded. This consisted of 84 nest crawls, 11 non-nesting crawls and 84 nest spots. Nine *C. mydas* crawls and nests, comprising 4 nest crawls, 1 non-nesting crawls and 4 nest spots and 149 *D. coriacea* crawls and nests, consisting of 73 nest crawls, 3 non-nesting crawls and 73 nest spots were recorded (Figure 26).

Within 2018 - 2019 sampling period, 72 *L. olivacea* crawls and nests were encountered. This consisted of 34 nest crawls, 4 non-nesting crawls and 34 nest spots. Three hundred and four *D. coriacea* turtles crawls and nests, consisting of 152 nest crawls and 152 nest spots were recorded. No non-nesting crawls were recorded for this species during the period. However, only 1 non-nesting track of *C. mydas* representing 0.14% was recorded (Figure 27).

Nest crawls and nest spots depicted two peak patterns in 2017 - 2018 (Figure 26). The concentration periods were from June 2017 to September 2017 and November 2017 to February 2018. Non-nesting crawls however, showed a staggering pattern for all the species during the same sampling period (Figure 26).

Comparatively, there was rather sharp deviation of crawls and nest activities between 2017 - 2018 and 2018 - 2019 sampling period. There was a single peak season and the concentrations of activities were between September 2018 and February 2019 (Figure 27). The single peak was as a result of late emergence and nesting pattern of the turtle species encountered in 2018 - 2019 nesting season. Non-nesting crawls of species however, displayed uneven pattern not quite different from 2017 - 2018 season (Figure 27).

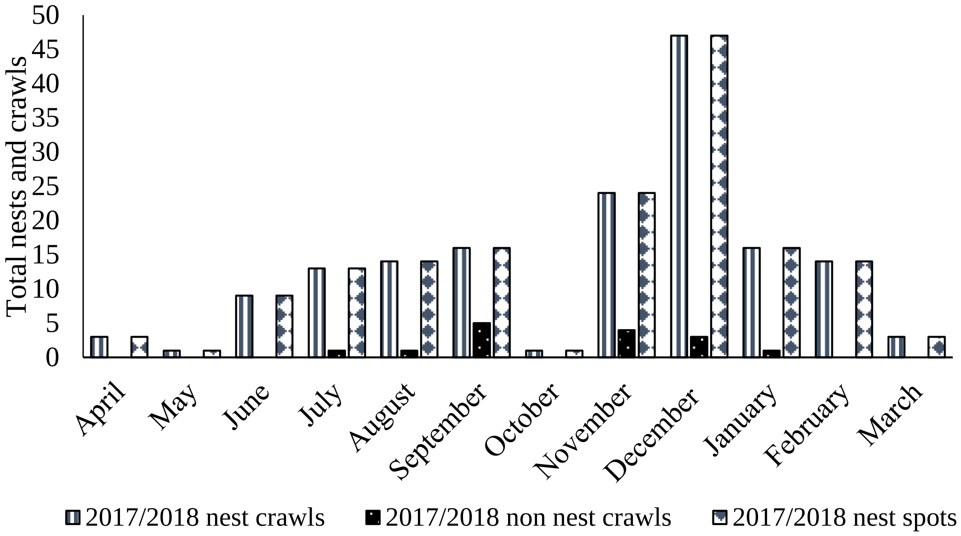

Figure 27: Seasonal distribution of turtle nests and crawls recorded for all species, 2017 – 2018 at Songor Ramsar Site

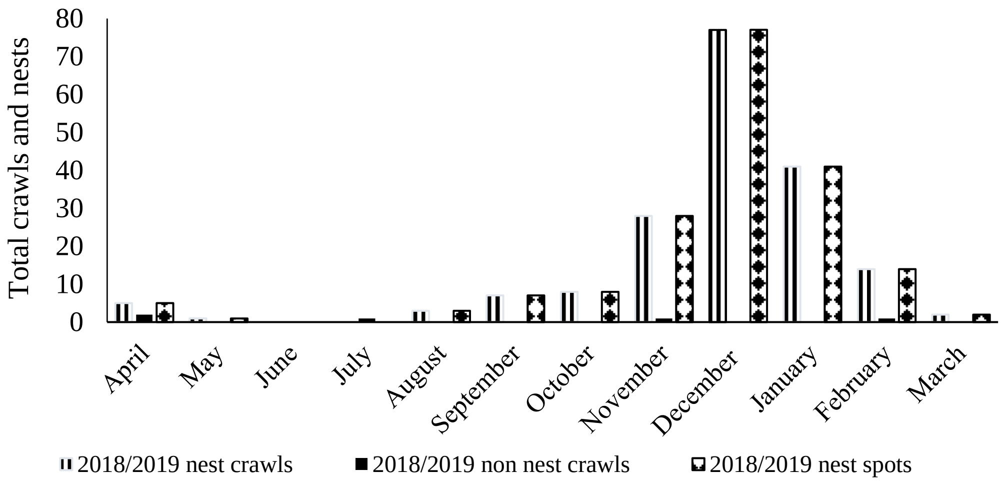

Figure 28: Seasonal distribution of turtle nests and crawls recorded for all species, 2018 – 2019 at Songor Ramsar site

Spatial distributions of species nests were influenced by physical nature of the shoreline. *Lepidochelys olivacea* nests were densest per kilometer square (km^2) during the 2017 - 2018 sampling period with a density of 2.1/km^2. The *D. coriacea* turtle species was 1.83/km^2 whiles *C. mydas* was 0.1/km^2. During the

2018 - 2019 sampling period the *D. coriacea* turtle species was the densest with a value of 3.8/km^2, *L. olivacea* was 0.5/km^2, whiles *C. mydas* was 0.03/km^2.

Spatial Distribution of Turtle Crawls and Nests at the Keta Lagoon Complex Ramsar Site

A total of 468 turtle crawls and nest were recorded within the area during the sampling periods (Appendix 3). This constituted 102 *L. olivacea* turtle crawls and nests and 366 *D. coriacea* turtles crawls and nests. No *C. mydas* activity was recorded within the sampling area.

Variations in crawls and nests between species and within the sampling periods occurred. During 2017 - 2018 sampling period, 34 *L. olivacea* activities comprising 17 nest crawls, 1 non-nesting crawls and 16 nest spots were encountered. During the same period 132 *D. coriacea* turtle activities constituting 66 nesting crawls and 66 nest spots were recorded (Figure 28).

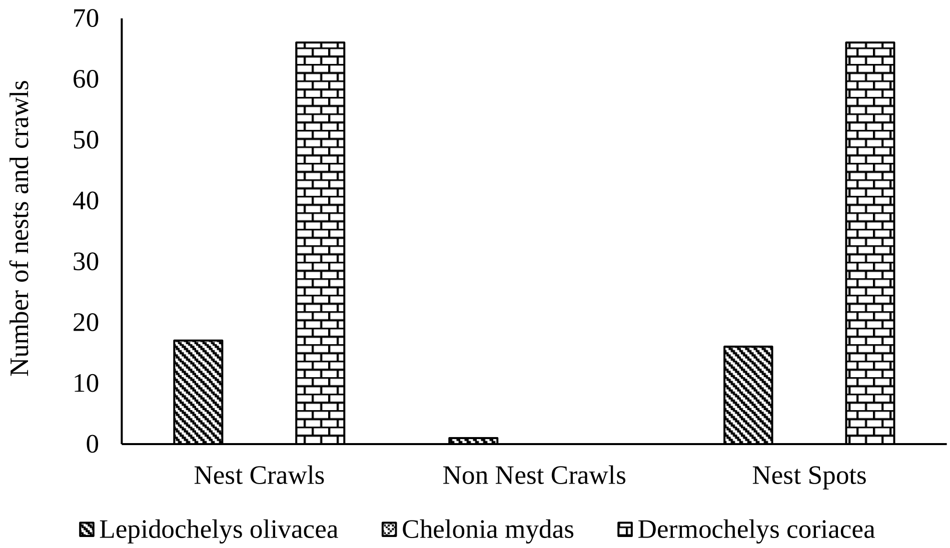

Figure 29: Number of nests and crawls of all species, 2017 – 2018 recorded at the Keta Ramsar site

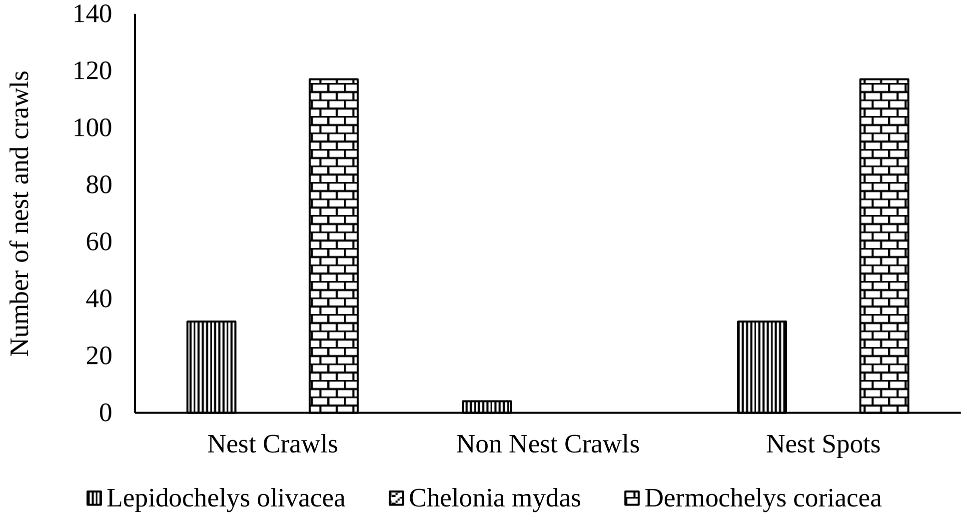

Figure 30: Number of nests and crawls of all species, 2018 – 2019 recorded at the Keta Ramsar site

Within the 2018 - 2019 sampling period, 68 *L. olivacea* activities consisting of 32 nest crawls, 4 non-nesting crawls and 32 nest spots were recorded, whiles 234 *D. coriacea* turtle activities comprising 117 nesting crawls and 117 nest spots occurred (Figure 29).

Variations in turtle crawls and nests occurred between sampling sites and periods. Seventeen (17) *L. olivacea* turtle crawls and nests activities were encountered in sampling site 1, whiles 14 and 4 were located within sampling site 3 and 4 respectively during 2017 - 2018 sampling period (Figure 30). During the same period, 72 *D. coriacea* turtle crawls and nests activities were recorded in sampling site 1, whiles 6 activities were recorded in site 2, 52 activities in site 3 and 2 activities in site 4.

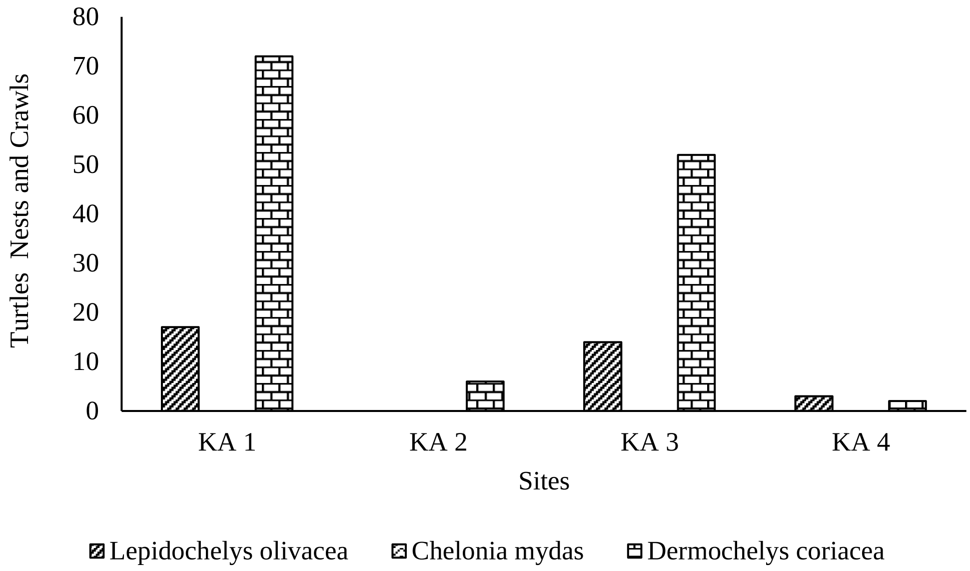

Figure 31: Number of nests and crawls at different sites, 2017 – 2018 recorded at the Keta Ramsar site

In 2018 - 2019 sampling period 39 *L. olivacea* turtle crawls and nests activities were recorded in sampling site 1, 5 in site 2 and 24 activities in site 3 (Figure 31). However, no activity was recorded in site 4. Within the same period 88 *D. coriacea* turtle crawls and nests activities were recorded in sampling site 1, 54 in site 2, 78 activities in site 3 and 14 activities in site 4. An increase of 55.30% turtle crawls and nest activities were observed in 2018 - 2019 sampling period.

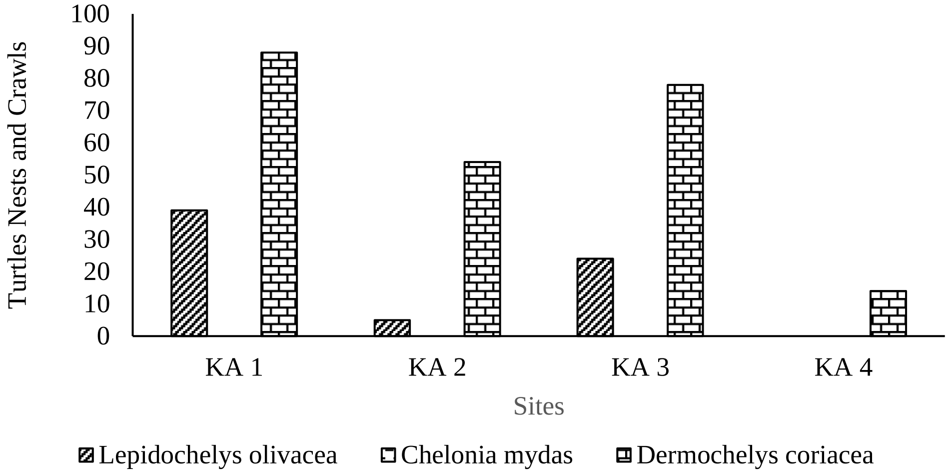

Figure 32: Number of nests and crawls at different sites, 2018 – 2019 recorded at the Keta Ramsar site

There was no significant difference between the mean turtle nest crawls within 2017 - 2018 and 2018 - 2019 sampling periods (p = 0.230) (Appendix 54). One peak season of nest crawls and nest spot activities were recorded during the 2017 - 2018 periods (Figure 32). Concentrations of activities were between October 2017 and January 2018. The nesting season of the *D. coriacea* were between these months and this might contribute to this pattern displayed. The only non-nesting crawl was recorded in September 2017. Two activity peaks were recorded in 2018 - 2019 periods (Figure 33). This occurred in July 2017 and between November 2017 and February 2018. The concentration period was between November 2017 and February 2018. The July 2017 peak was due to a single emergence and nesting activities of *L. olivacea*.

Dermochelys coriacea were widely distributed than any other species encountered during the sampling periods (Appendix 4). The nests were densest in 2018 - 2019 and 2017 - 2018 with a density of 2.49/km^2 and 4.0/km^2

respectively. *Lepidochelys olivacea* turtles had a density of 0.34/km^2 during 2017 - 2018 sampling period and 0.68/km^2 during 2018 - 2019.

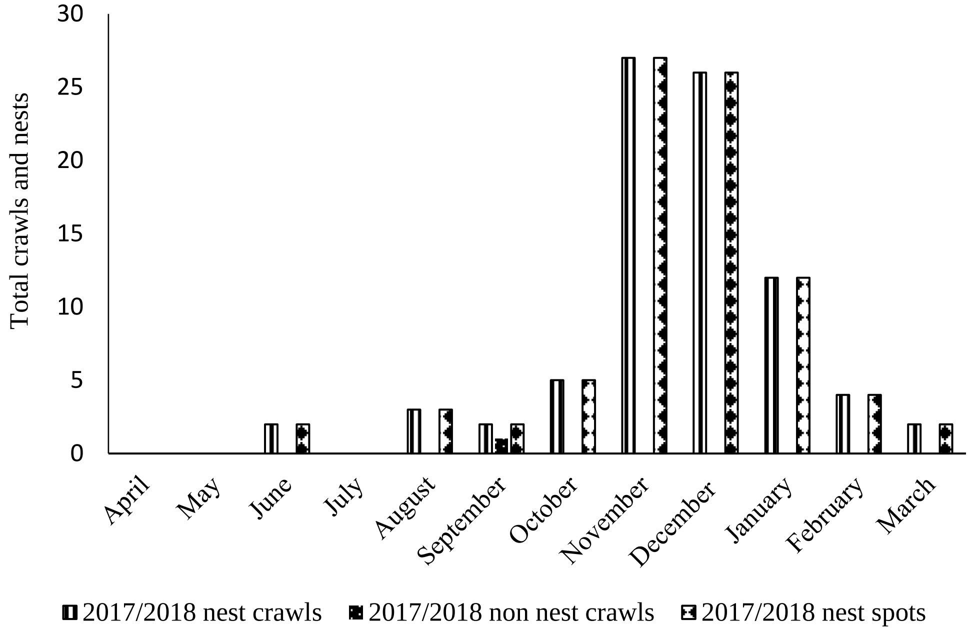

Figure 33: Seasonal distribution of turtle nests and crawls 2017 – 2018 at Keta Ramsar site

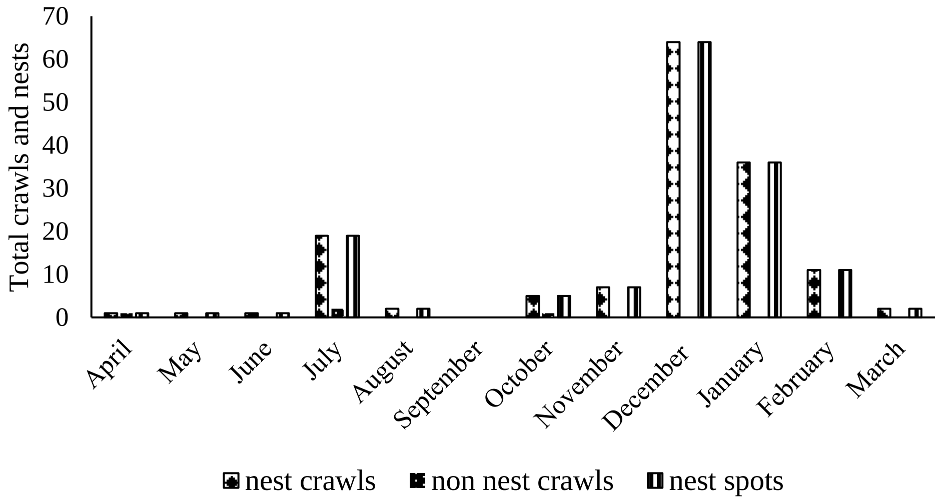

Figure 34: Seasonal distribution of turtle nests and crawls, 2018 – 2019 recorded at the Keta Ramsar site

Successful Turtle Nests with Hatched Eggs at Songor Ramsar Site

A total of 579 turtle nests were recorded during the sampling period. Out of these 19 turtle nests with hatched eggs of 2 species representing 3.28% of total nests were observed within the sampling area (Figure 34). This comprised of 12 *L. olivacea* and 7 *D. coriacea*.

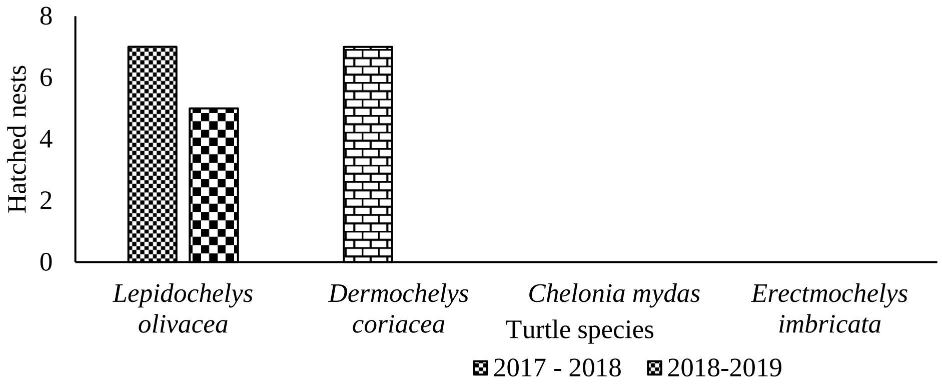

Figure 35: Nest with hatched eggs observed, 2017 – 2019 at Songor Ramsar site.

During 2017 - 2018 sampling period, 4 *L. olivacea* and 1 *D. coriacea* nests with hatched eggs were encountered within sample site 1. During the same period, 3 *L. olivacea* and 6 *D. coriacea* nests with hatched eggs were observed within sample site 2. (Figure 35).

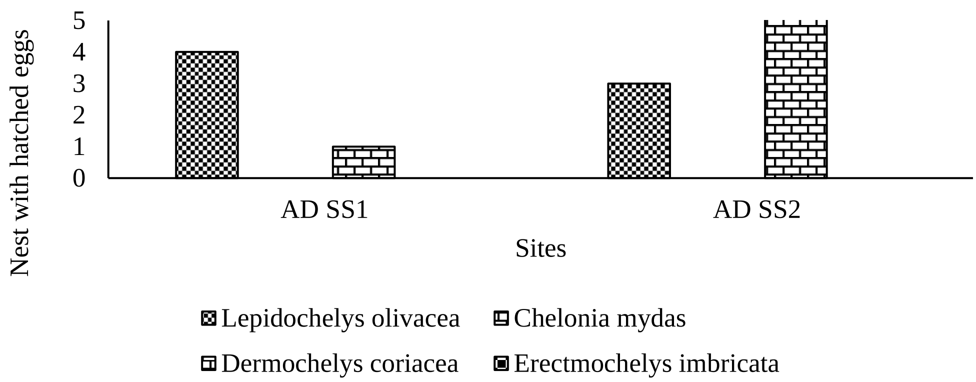

Figure 36: Nest with hatched eggs at different sites, 2017 – 2018 at Songor Ramsar site.

Within 2018 - 2019 nesting period, 4 L. olivacea nests with hatched eggs were encountered in sampling site 1. Within sample site 2, 1 *L. olivacea* nest with hatched eggs was recorded (Figure 36).

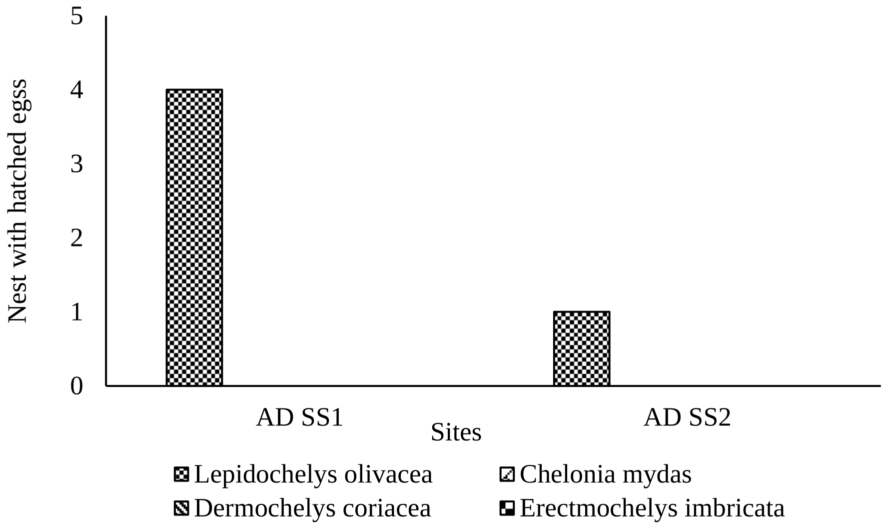

Figure 37: Nest with hatched eggs at different sites, 2018-2019 at Songor Ramsar site

Seasonal variations in turtle nests with hatched eggs were observed. During 2017 - 2018 nesting seasons, the activities were unevenly distributed (Figure 37). Nests with hatched eggs were concentrated within the last three quarters of the sampling period, accounting for 57.9% of the activities of the season, January 2018, February 2018 and March 2018. There were marginal activities in April 2017, 1 and October 2018, 2. The 2018 - 2019 season depicted irregular pattern with no clear peak nor concentration periods. Five activities occurred within two months, 2 in June 2018 and 3 in February 2019 (Figure 37).

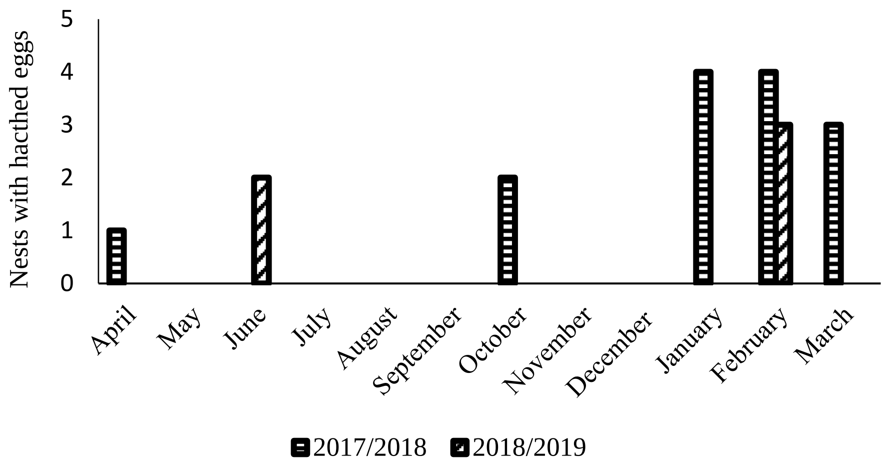

Figure 38: Seasonal distribution of nests with hatched eggs observed 2017 - 2019 at Songor Ramsar site.

Successful Turtle Nests with Hatched Eggs at Keta Ramsar Site

Within the sampling area 9 *L. olivacea* and 5 *D. coriacea* nests with hatched eggs were observed during the sampling period as indicated in Figure 38.

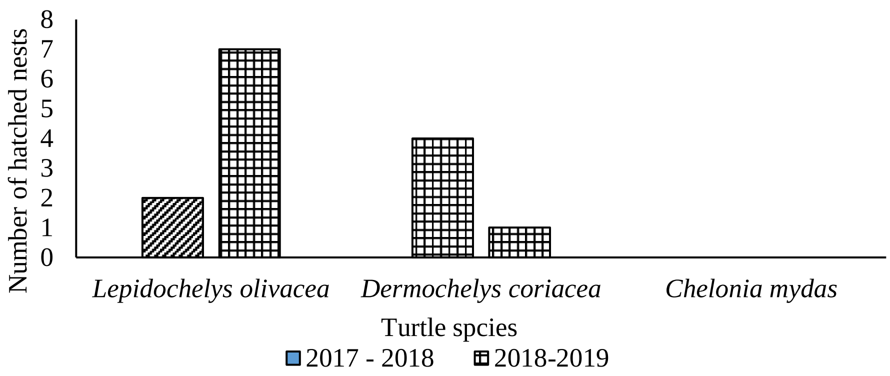

Figure 39: Nest with hatched eggs observed, 2017 – 2019 at Keta Ramsar site

Variations in nests with hatched eggs were observed within the sampling site during the sampling periods. During 2017 - 2018 nesting periods, 2 *L. olivacea* nest with hatched eggs were observed in sample sites 1 and 3 (Figure

39). During the same period 4 *D. coriacea* nests with hatched eggs were encountered in sample site 1.

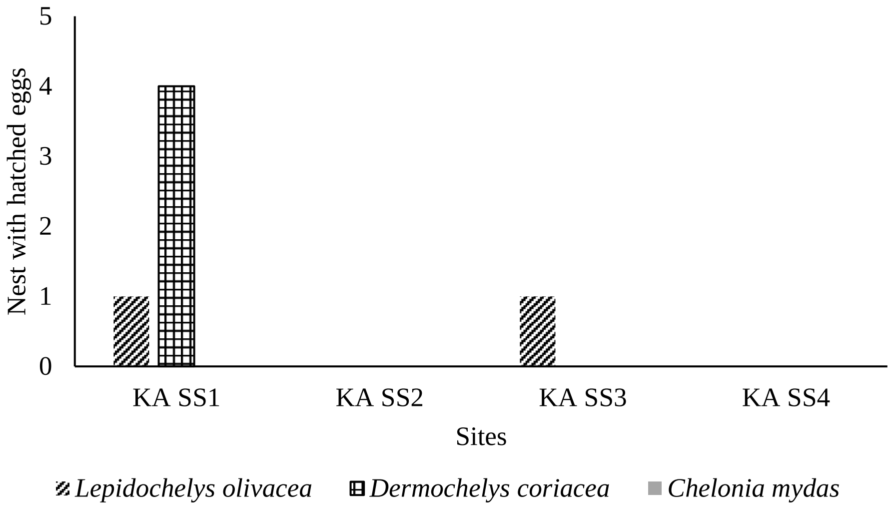

Figure 40: Nest with hatched eggs at different sites, 2017 – 2018 at Keta Ramsar site.

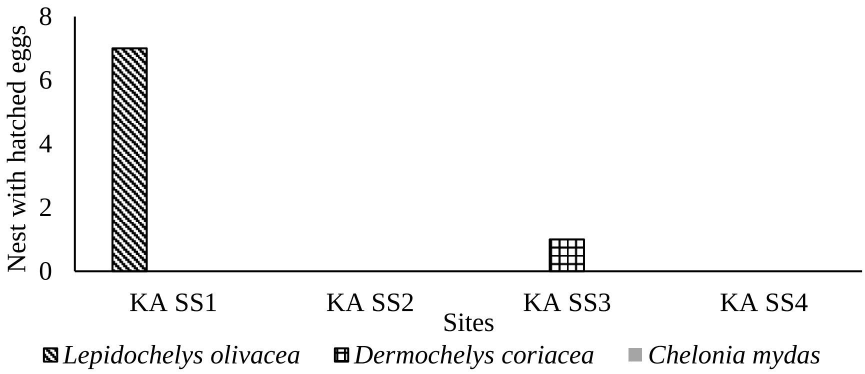

Figure 41: Nest with hatched eggs at different sites, 2018 – 2019 at Keta Ramsar site.

In 2018 - 2019 sampling period, Seven *L. olivacea* were encountered in site 1 whiles 1 *D. coriacea* nests with hatched eggs were recorded in sampling site 3 (Figure 40).

Data on seasonal nests with hatched eggs in 2017 - 2018 were unevenly displayed. The activity which was concentrated within the last quarter of the sampling period, depicted marginal figures within the sampled months, 1 in January 2018, 2 in both February 2018 and March 2018 (Figure 41). Within the second quarter of the sampling period, 1 nest with hatched eggs was recorded in April 2017. During 2018 - 2019 seasons, the information displayed does not deviate significantly from 2017 - 2018. Five activities were recorded, with the concentration period between April 2018 and May 2018. Thereafter, there were marginal activities, 1 in September 2018 and 2 in March 2019. (Figure 41).

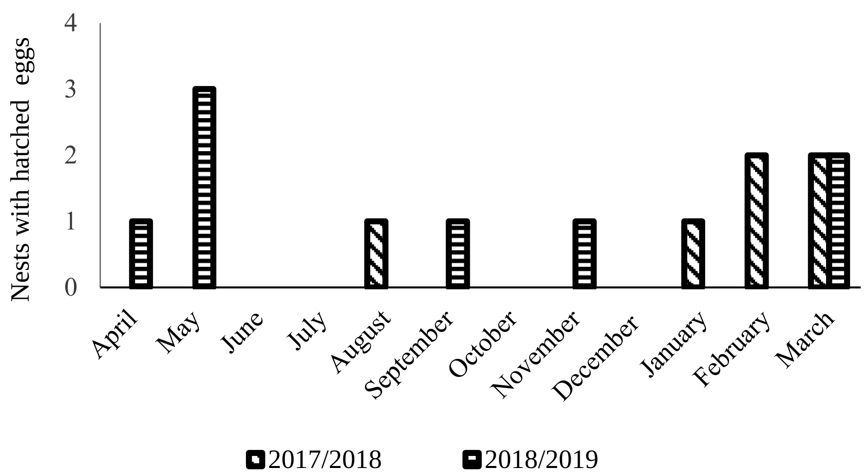

Figure 42: Seasonal distribution of nests with hatched eggs, 2017 - 2019 at Keta Ramsar site.

Occurrence of Turtle Hatchlings at the Songor Ramsar Site

A total of 240 hatchlings from successfully hatched eggs were recorded. This constituted 151 *L. olivacea* and 89 *D. coriacea* hatchlings (Figure 42). No turtle hatchlings were observed during 2018 - 2019 sampling period.

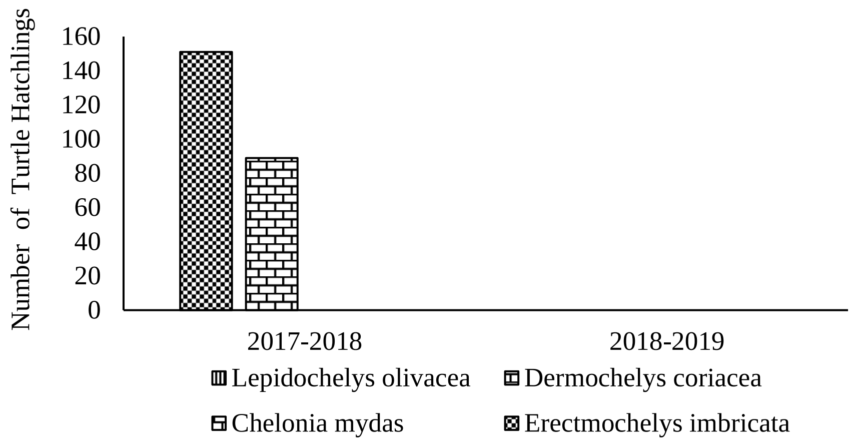

Figure 43: Total turtle hatchlings recorded at Songor Ramsar site, 2017 – 2019

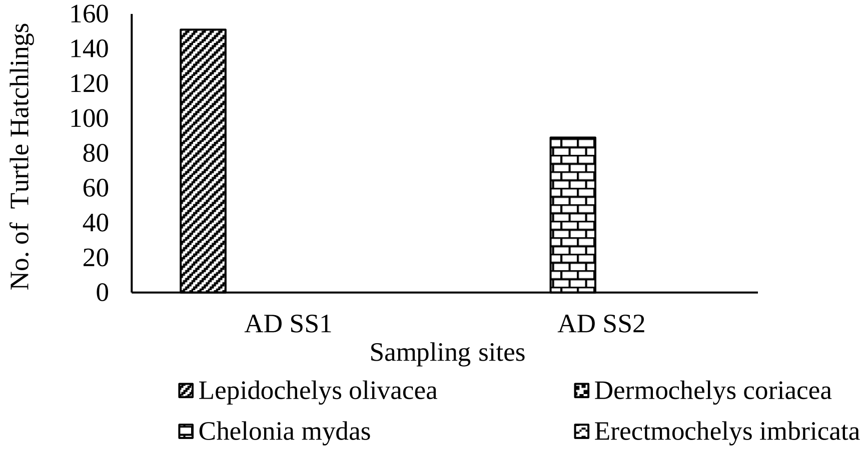

Figure 44: Total turtle hatchlings recorded at different sampling sites, 2017-2018. at Songor Ramsar site

Within sample site 1, 151 *L. olivacea* hatchlings were recorded whiles 89 *D. coriacea* hatchlings were recorded in sample site 2 (Figure 43).

Number of turtle hatchlings observed varied within the sampling season. Within 2017 – 2018 season, *L. olivace* hatchlings were observed twice, 12 hatchlings in April 2017 and 139 in October 2017. No turtle hatchlings were observed during the 2018 - 2019 seasons (Figure 44). *D. coriacea* hatchlings were observed emerging from the nest in sampling site 2 (Figure 45).

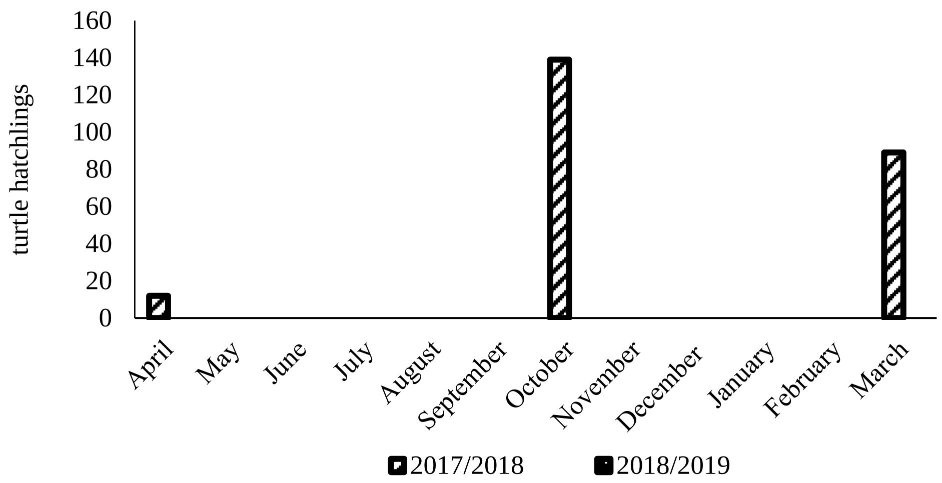

Figure 45: Seasonal distribution of turtle hatchlings recorded, 2017 - 2019 at Songor Ramsar site

Figure 46: Leatherback turtle hatchlings emerging from nests at Songor Ramsar site

Occurrence of Turtle Hatchlings at *the Keta Lagoon Complex Ramsar site*

Within the sampling area a total of 66 turtle hatchlings were encountered comprising 48 *L. olivacea* and 18 *D. coriacea* hatchlings (Figure 46).

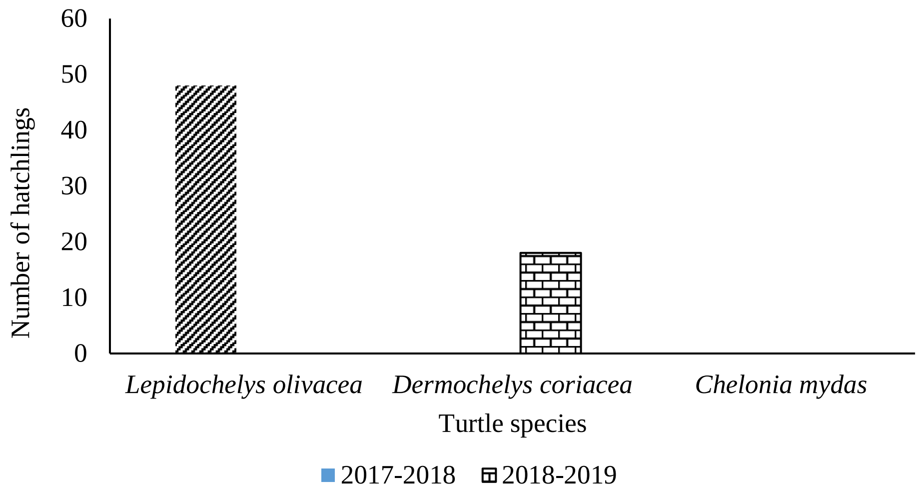

Figure 47: Number of turtle hatchlings recorded, 2017-2019 at Keta Ramsar site.

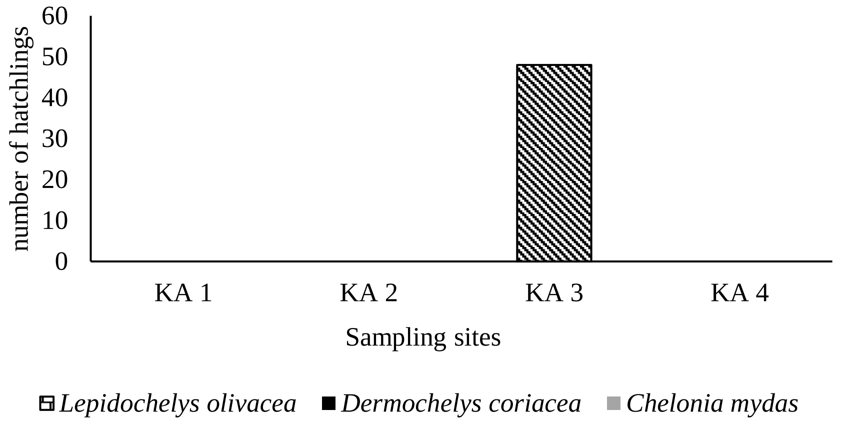

Figure 48: Total turtle hatchlings recorded at different sampling sites, 2017-2018 at Keta Ramsar site

During 2017 - 2018 sampling period, 48 *L. olivacea* hatchlings were encountered within sampling site 3, whiles 18 *D. coriacea* hatchlings were recorded within sampling site 3 during 2018 - 2019 sampling period (Figure 47 and 48).

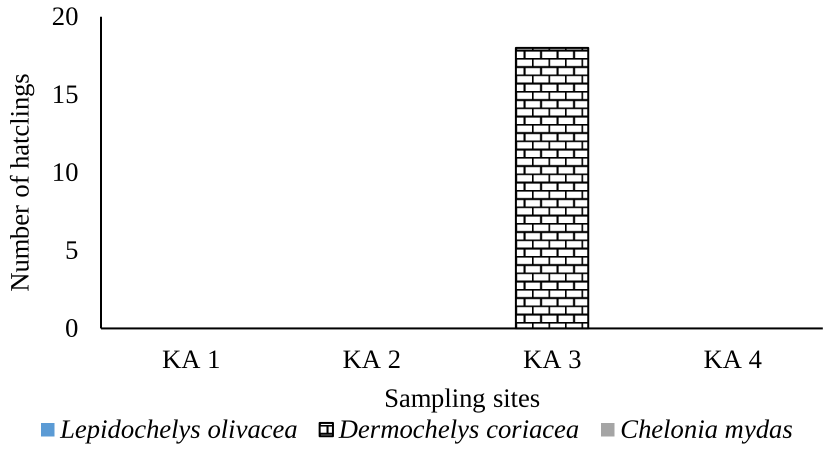

Figure 49: Total turtle hatchlings recorded at different sampling sites, 2018 – 2019 at Keta Ramsar site

Seasonal hatchlings activities observed during the sampling periods were discreet. There were 2 occurrences, one in each season. Forty-eight hatchlings were recorded in August, 2017 - 2018 sampling period and 18 hatchlings in March, 2018 - 2019 sampling period. There were no clear peak and concentration period of activities during the season (Figure 49).

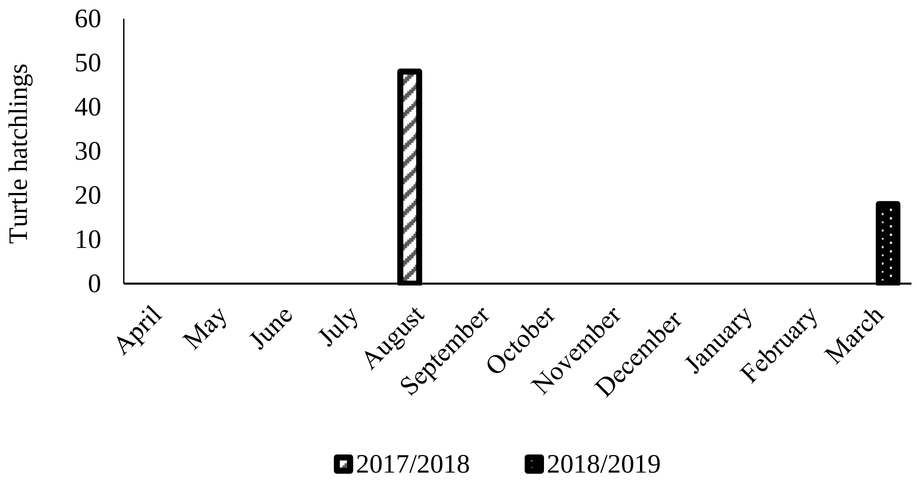

Figure 50: Seasonal distribution of turtle hatchlings 2017 - 2019 at Keta Ramsar site

Turtle Nest with Egg Predatory Activities at Songor Ramsar Site

A total of 121 turtle nest with egg predatory activities were recorded during the sampling period. This comprised of 114 successful turtle nests with egg predation and 7 unsuccessful predatory attempts (USPA) as indicated in figure 45. Turtle nests with egg predatory activities were observed to vary between the species recorded. One hundred and twelve *L. olivacea* nests with egg predatory activities were recorded. These comprised of 107 successful turtle nests with egg predations and 5 unsuccessful attempts. Nine *D. coriacea* turtle nests with egg predatory activities comprising 7 successful and 2 unsuccessful nests with egg predation attempts (Figure 50).

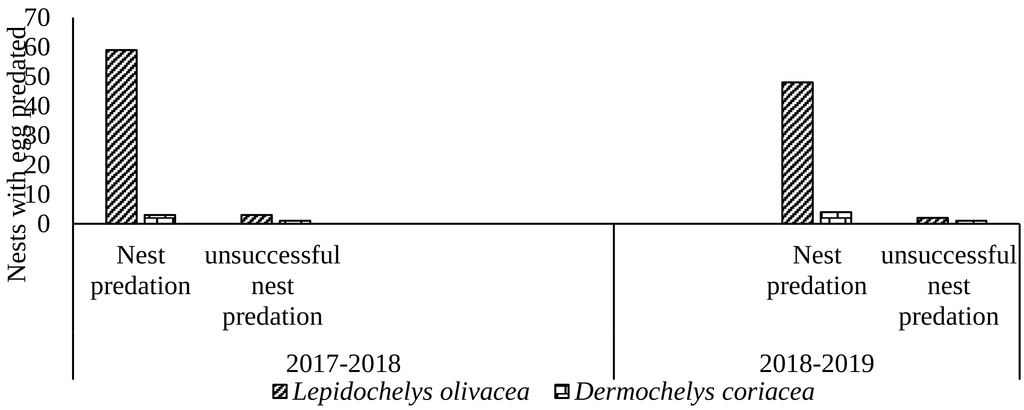

Figure 51: Total turtle nest with egg predation, 2017-2019 at Songor Ramsar site

One hundred and fourteen nests with egg predations were recorded during the sampling periods. During 2017 - 2018 sampling period, 59 *L. olivacea* and 3 *D. coriacea* nests with egg predations were recorded. Nine (9) *L. olivacea* nests with egg predations were recorded in sampling site 1, whilst 50 were observed in sampling site 2 during the same sampling period. Three *D. coriacea* turtle nests with egg predations occurred in sampling site 2 (Figure 51).

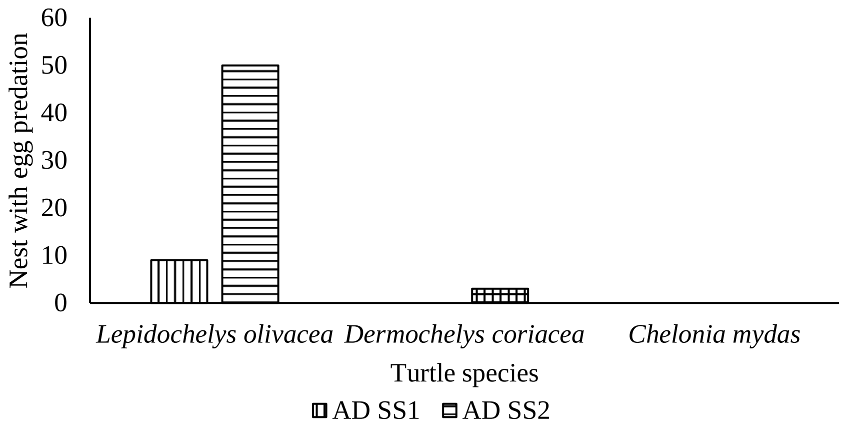

Figure 52: Nests with egg predation recorded at different sampling sites, 2017 – 2018 at Songor Ramsar site

Fifty-two turtle nests with egg predations were observed during 2018 - 2019 sampling period (Figure 52). This comprised of 48 *L. olivacea* and 4 *D. coriacea* nest with egg predations. Of these, 26 *L. olivacea* nest with egg predations occurred in sampling site 1, whilst 22 were recorded in sampling site 2. Four *Dermochelys coriacea* nest with egg predations were encountered in sampling site 2. No *D. coriacea* nest with egg predations occurred in sampling site 1.

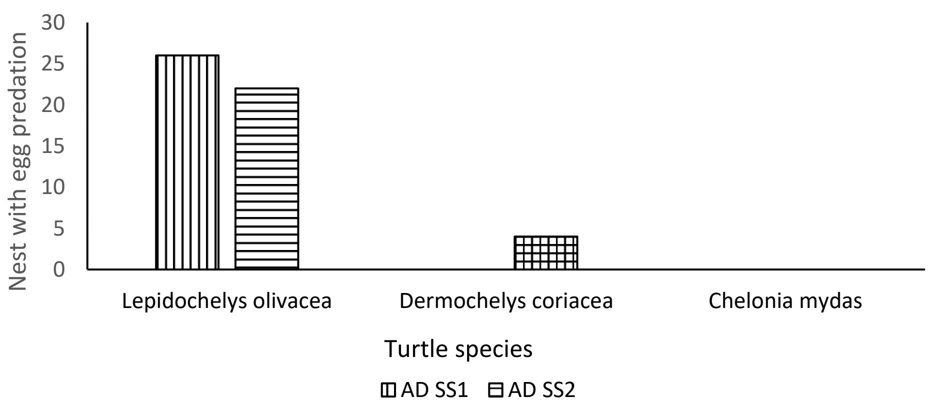

Figure 53: Nests with egg predation recorded at different sampling sites, 2018 – 2019 at Songor Ramsar site

Nests with egg predation that occurred were unevenly distributed during the sampling period. During 2017 - 2018 sampling period, 2 nests with egg predation peaks occurred between August 2017 to September 2017 and December 2017 to January 2018 (Figure 53). The concentration periods were between June 2017 to September 2017 and November 2017 to January 2018. However, during 2018 - 2019 sampling period one peak nest with egg predation was observed from December 2018 to February 2019. The concentration period varied from September 2018 to February 2019. The highest nests with egg predations activity, 14, occurred during this sampling period in January 2019 (Figure 53). It was observed that, 2018 - 2019 nests with egg predations activities were 8.77% lower than that of 2017- 2018.

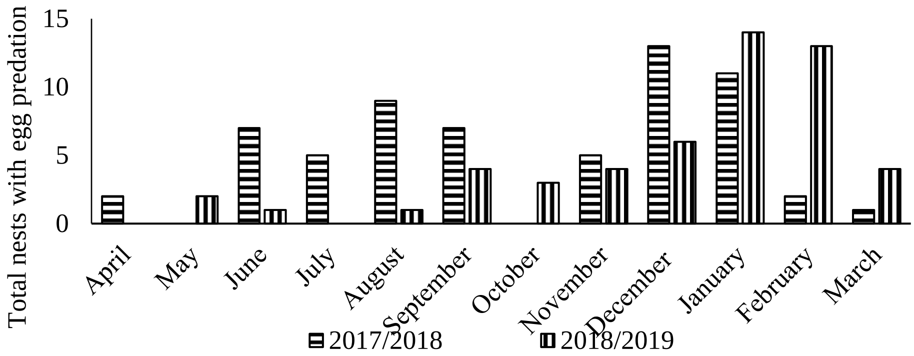

Figure 54: Seasonal distribution of nest with egg predation activities 2017 - 2019 at the Songor Ramsar site

Predators of turtle eggs at Songor Ramsar Site

Feral dogs, ghost crabs and humans were observed to be the main predators of turtle eggs within the sampling area. A total of 107 *L. olivacea* nests with eggs were preyed on during the sampling periods (Figure 54). Out of these, human preyed on 22, 42 by feral dogs and 16 mainly by ghost crabs *(Ocypodar* *cursor).* Human successfully preyed on 3 nests with eggs, whilst crabs preyed on 4 during the sampling period.

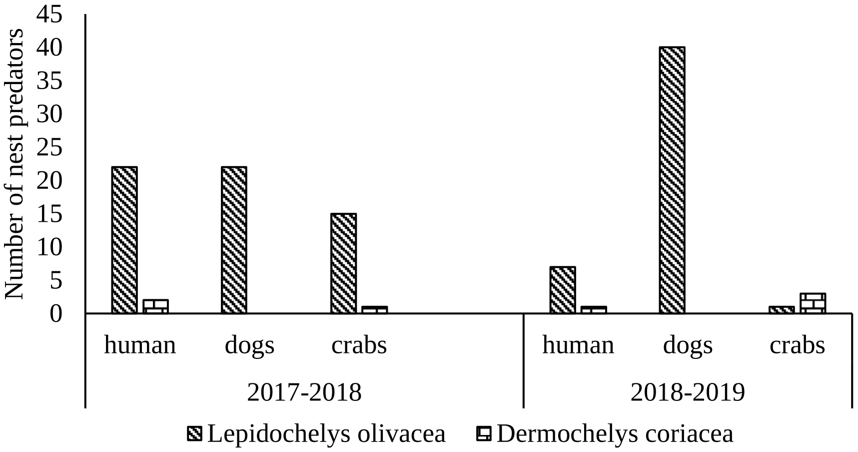

Figure 55: Predators of turtle nest with eggs, 2017 – 2019 at Songor Ramsar site

During 2017 - 2018 sampling period 62 nests with eggs were preyed on by 3 predators (Figure 55). Human preyed on 24 nests with eggs of which 1 occurred within sampling site 1 and 23 within sampling site 2. Dogs preyed on 22 nests with eggs during the same period, 7 occurred within sampling site 1 and 15 within sampling site 2. Crabs preyed on 16 nests with eggs, 1 was recorded within sampling site 1 whilst 15 occurred within sampling site 2.

In 2018 - 2019 sampling period, 52 nests with eggs were preyed on by human, dogs and ghost cabs (Figure 55). Human preyed on 8 turtle nests with eggs of which all occurred within sampling site 2. Dogs preyed on 40 turtle nests with eggs and out of these, 26 occurred within sampling site 1 and 14 occurred within sampling site 2. Four turtle nests with eggs were preyed on by crabs and all occurred within sampling site 2. Predators activities reduced marginally by 8.77% in 2018 - 2019 sampling period. Dogs were the most successful nests predators. Dogs preyed on 62 nests as compared to 32 by human and 20 by crabs respectively during the sampling periods (Figure 55).

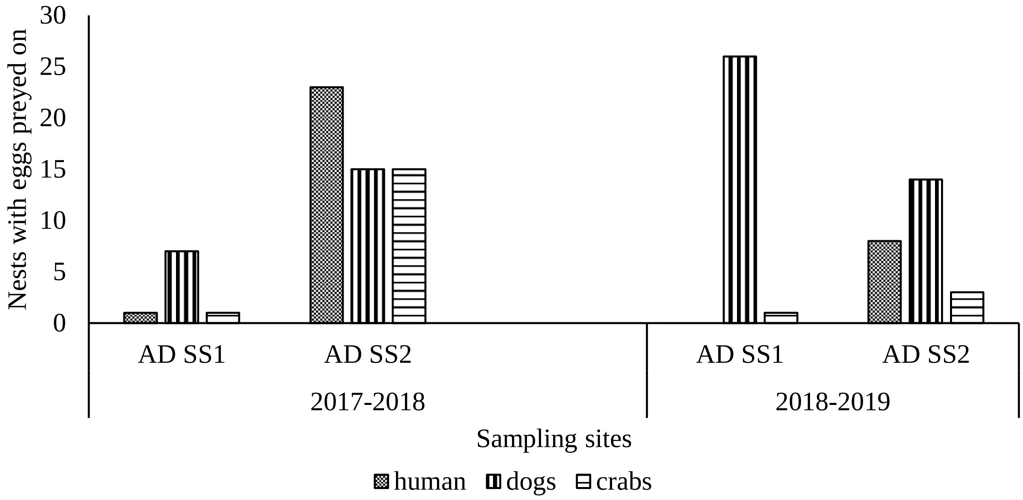

Figure 56: Number of nests with eggs preyed on, 2017-2019 at Songor Ramsar site.

During 2017 – 2018, human predatory activities were concentrated between June 2017, August 2017 and December 2017 (Figure 56). Activities of dogs were sparsely distributed. It peaked between November 2017 and December 2017. The concentration periods were between July 2017 and December 2017. Activities of ghost crabs were also unevenly distributed. The concentrations were between July 2017 and September 2017, November 2017 and December 2017, February 2018 and March 2018. The activity however peaked marginally between November 2017 and December 2017.

2018 - 2019 sampling period presented a drop in all nest predatory activities with the exception of dogs (Figure 57). Activities of human predators were sparsely distributed. It occurred 8 months within the sampling period, with a marginal peak in November 2018 (4). Activities of dogs were unevenly distributed within the period. The concentrations were between May 2018 and

June 2018, August 2018 to October 2018 and December 2018 to March 2019. Dog activities increased by 15.79% within the sampling period. Activities of crab dropped by 10.53% within the sampling period, occurring only in February 2019 and March 2019. Only one peak period was recorded in February 2019 (3). The activities were concentrated between February 2019 and March 2019 within the same sampling period.

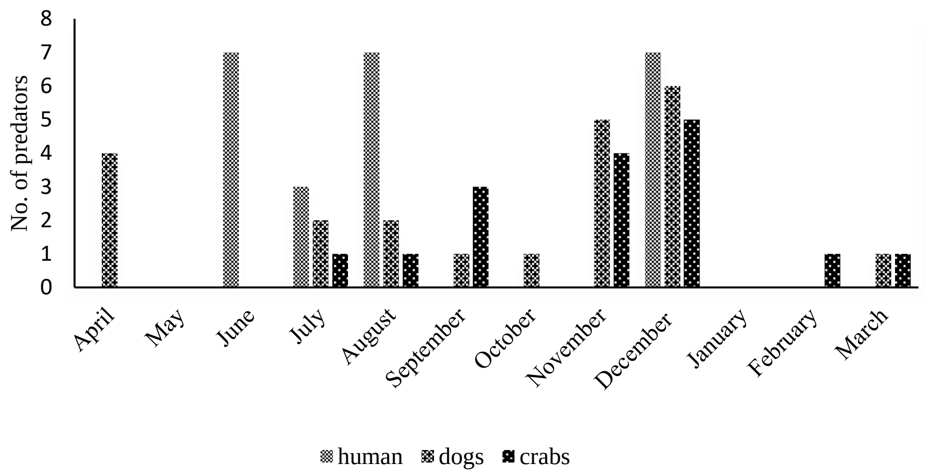

Figure 57: Distribution of nest with egg predatory activities, 2017 - 2018 at Songor Ramsar site

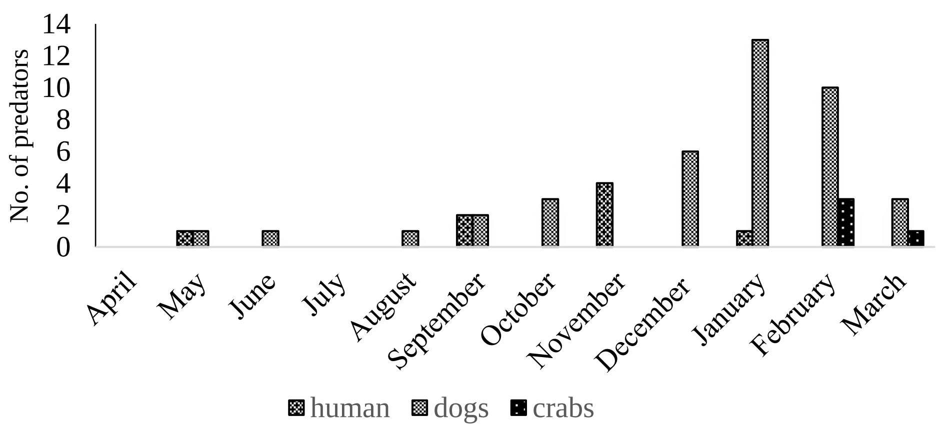

Figure 58: Distribution of nest with egg predatory activities, 2018 – 2019 at Songor Ramsar site

Turtle Nest with Egg Predatory Activities at Keta Lagoon Complex Ramsar sites

Within the sampling area, a total of 68 nests with egg predatory activities were recorded during the sampling period comprising 64 successful and 4 unsuccessful nests with egg predation attempts (Figure 58). Nest with egg predatory activities varied between turtle species observed within the sampling period. Sixty - one *L. olivacea* predatory activities were recorded. These comprised of 59 successful and 2 unsuccessful nests with egg predation attempts. Seven *D. coriacea* predatory activities were encountered constituting 5 successful and 2 unsuccessful nests with egg predation attempts (Figure 58).

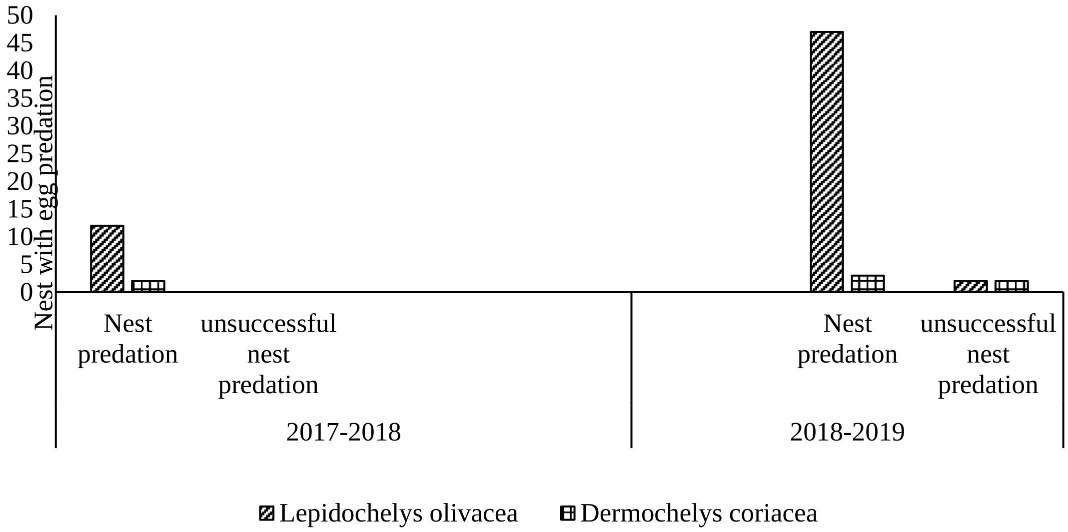

Figure 59: Predators of turtle nest with eggs, 2017 – 2019 at Keta Ramsar site

It was observed that nest with egg predatory activities varied between sampled sites during the periods (Figure 59). During 2017 - 2018 period, 8 nests with egg predation activities occurred in sampling site 1 comprising 6 Olive *L olivacea* and 2 *D. coriacea* successful nests predation. Two successful *L. olivacea* nests with egg predation occurred in sampling site 3, whiles 4 nests with egg predations of the same species were recorded in sampling site 4 (Figure 59).

In 2018 - 2019 sampling period 50 successful nests with egg predation activities were recorded depicting an increase of 55.8% (Figure 59). The highest successful nests with egg predation, 42, was recorded in sampling site 1 (KA SS1) for the *L. olivacea.* During the same sampling period, 2 *D. coriacea* nests with egg predations were recorded. Within sampling site 2, 4 *L. olivacea* and 1 *D. coriacea* successful nests with egg predations were observed. Within sampling site 4, 1 *L. olivacea* nest with egg predation was recorded (Figure 59).

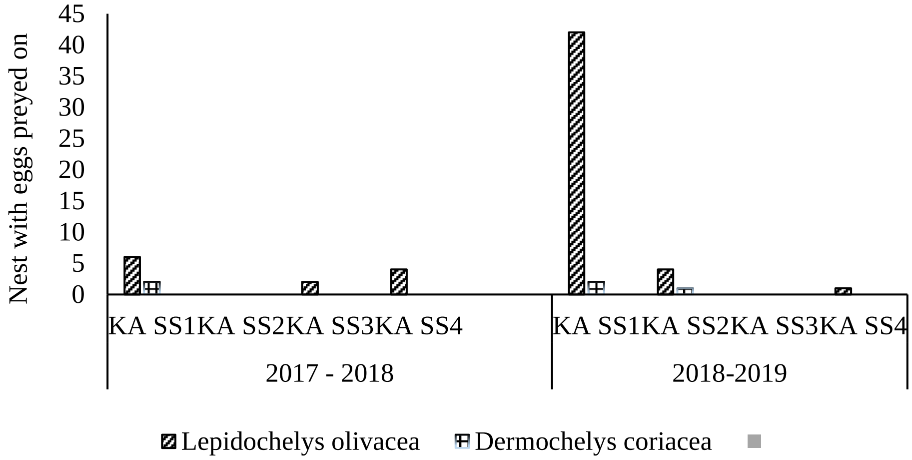

Figure 60: Number of nests with eggs preyed on, 2017-2019 at Keta Ramsar site

Seasonal variations in nests with egg predation activities occurred during the sampling periods (Figure 60). During 2017 - 2018, sparse distribution of nests with egg predation activities occurred in June 2017, August 2017, September 2017, November 2017 and January 2018. Only one peak period was displayed in September 2017 with highest nests with egg predation activities (6). During 2018 - 2019 sampling period, nests with egg predation activities were unevenly distributed. There were three peak periods within the season, July 2018 (8), January 2019 (13) and March 2019 (7). The concentration periods were between July 2018 to March 2019 and November 2018 to March 2019 (Figure 60).

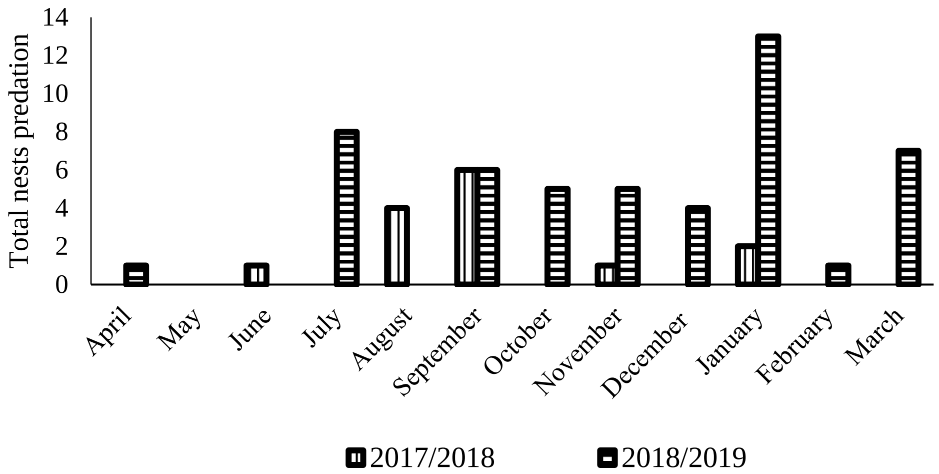

Figure 61: Seasonal distribution of nests with egg predations, 2017 - 2019 at Keta Ramsar site

Predators of Turtle Eggs at the Keta Lagoon Complex Ramsar Site

During the sampling periods, 4 nests with egg predators were observed comprising human, dogs, crabs and pigs (Figure 61). A total of 59 nests of *L. olivacea* were preyed on. Human preyed on 14 *L. olivacea* turtle nests with egg, 30 by feral dogs, 13 by ghost crabs and 2 by pigs. Five *D. coriacea* nests with egg were preyed on; 3 by human and 2 by ghost crabs. However, no turtle species nest with egg was preyed on by dogs.

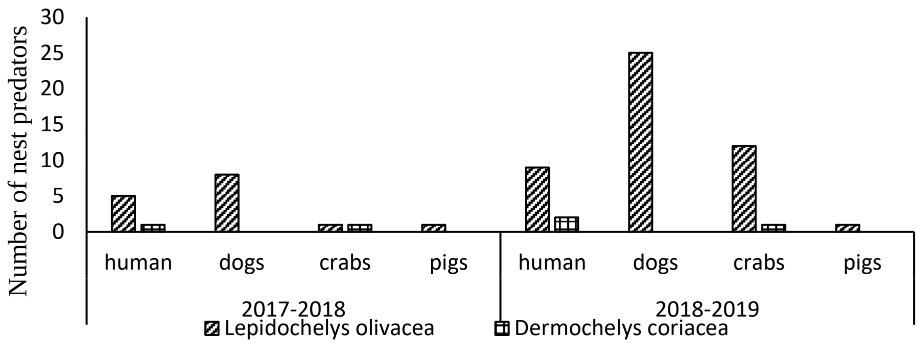

Figure 62: Predators of turtle nests with eggs, 2017 – 2019 at the Keta Ramsar site.

A total of 14 sampled predators activities occurred in 2017 - 2018 sampling period (Figure 62). Eight of the predator activities were recorded in sampling site 1 of which human preyed on 2 nests with egg; dogs preyed on 3, crabs preyed on 2 whilst pigs preyed on 1. Two human activities were recorded in sampling site 3. Four predator activities were encountered in sampling site 4, of these human and dogs preyed on 2 each. During 2018 - 2019 sampling period, 50 nests with egg predator activities were sampled (Figure 62). Forty of these activities were recorded in sample site 1, of these human successfully preyed on 5 nests with egg, dogs preyed on 22 nests with egg, crabs preyed on 12 nests with egg with whiles pigs preyed on 1. One human nest predator activity was recorded in sample site 2. Seven nests with egg predator activities were encountered in sample site 3, comprising 5 successful human predation, 1 dog and 1 crab predation. Two dog predation activities were observed in sampling site 4.

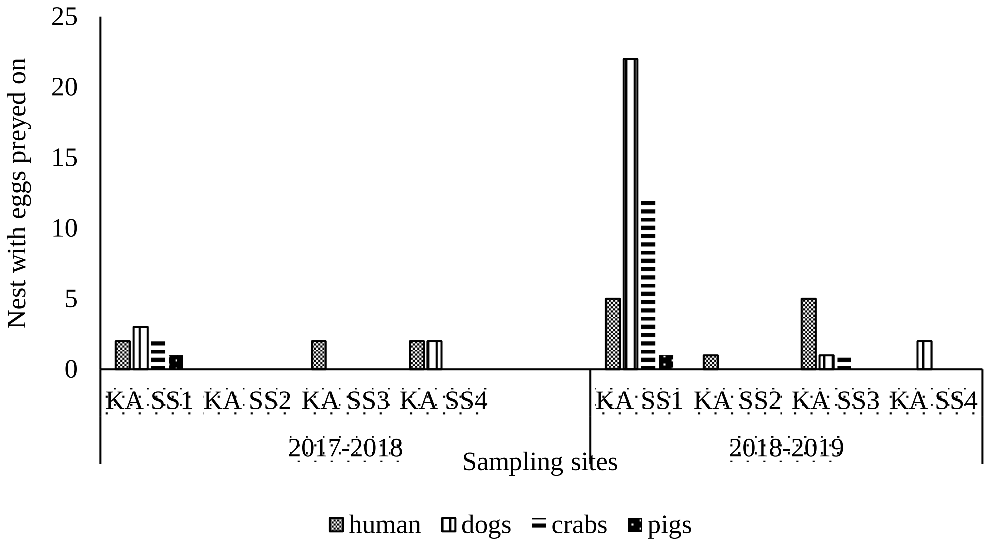

Figure 63: Number of nests with eggs preyed on, 2017 - 2019 at Keta Ramsar site

Variations in nests with egg predator activities within the year were observed during the sampling period. Within the 2017 - 2018 periods, predator activities were sparsely distributed. Human activities occurred four times during the period from June 2017, September 2017, December 2017 and January 2018. There was one marginal peak within the season in September 2017. The concentration period was between December 2017 and January 2018. Feral dogs activities occurred in July 2017, August 2017, September 2017 and November 2017 with a marginal increase in September 2017. The concentration periods were between July and September 2017. Crab activities occurred in September 2017 and January 2018 without any peak period. Pig activities occurred only once in September 2017 (Figure 63).

A copious distribution trend was depicted within the 2018 - 2019 sampling period especially by the three predators; human, dogs and crabs. Human activities showed one peak margin in July 2018 (4). The activities were concentrated between October 2018 and January 2019. The activity however dipped from November 2018 to January 2019. Dog activities displayed two peaks margin pattern during the period of September 2018 (4) and January 2019 (11). The concentration periods were between November 2018 and January 2019. Crab activities were virtually absent in the first quarter of the sampling period. The activities however, were concentrated between the months of July 2018 to February 2019. There was a marginal increase in the month of October 2018 (2). The activity increased dramatically in the month of March 2019 (5). Pig activity was marginally visible only in the month of September 2018 (Figure 64).

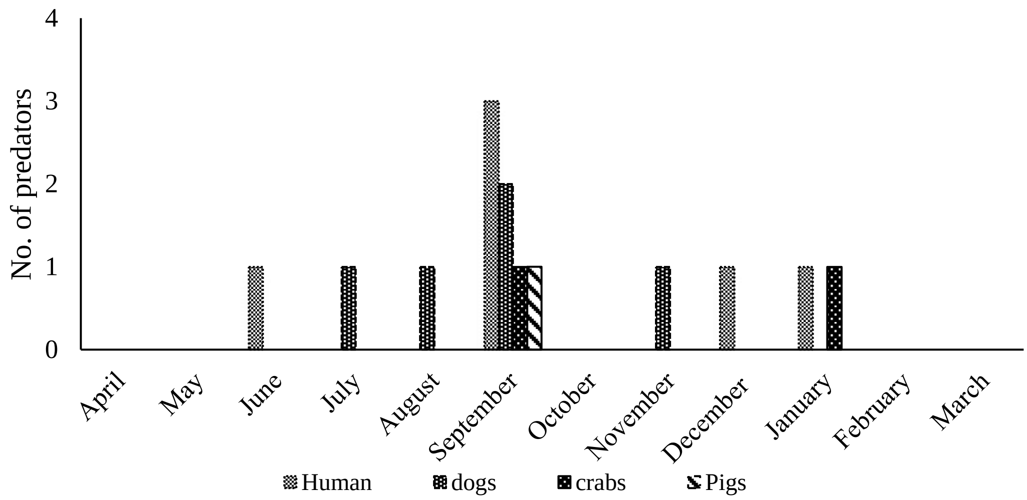

Figure 64: Distribution of nest with egg predatory activities, 2017 – 2018 at Keta Ramsar site

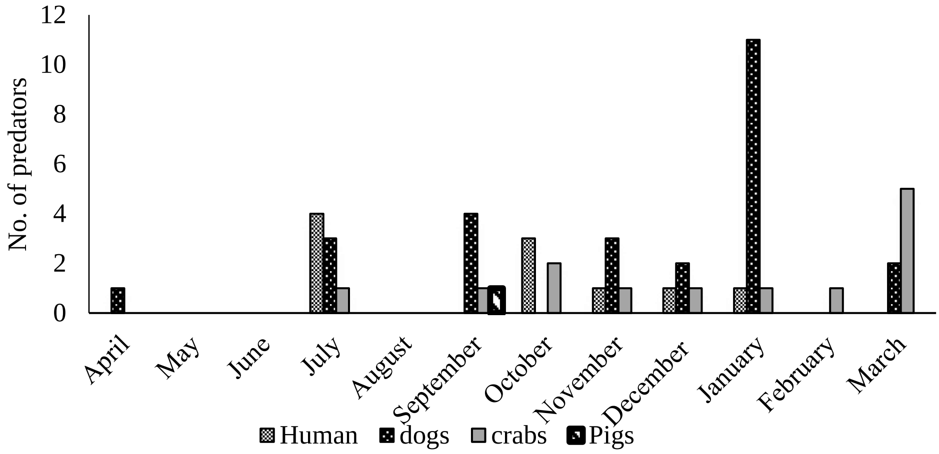

Figure 65: Distribution of nest with egg predatory activities, 2018 – 2019 at Keta Ramsar site

Occurrence of Poached Turtles at the Songor Ramsar Site

During the sampling periods 4 *L. olivacea* were poached within the sampling area, representing 6.2% of total poached turtles as indicated in Figure 65.

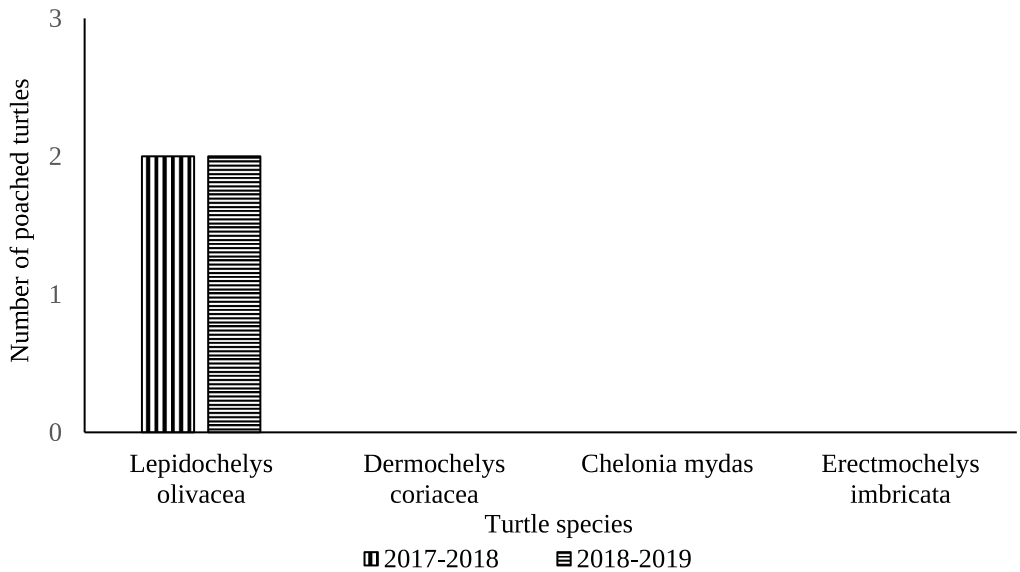

Figure 66: Total turtles and species poached, 2017 – 2019 at Songor Ramsar site

The number of turtles poached varied within the sampling periods (Figure 66). During 2017 - 2018, 2 *L. olivacea* were poached in sampling site 1. Two *L. olivacea* were pooched during 2018 - 2019 period within the same sampling site. There were no observed poaching activities within sampling site 2 during the sampling periods (Figure 66).

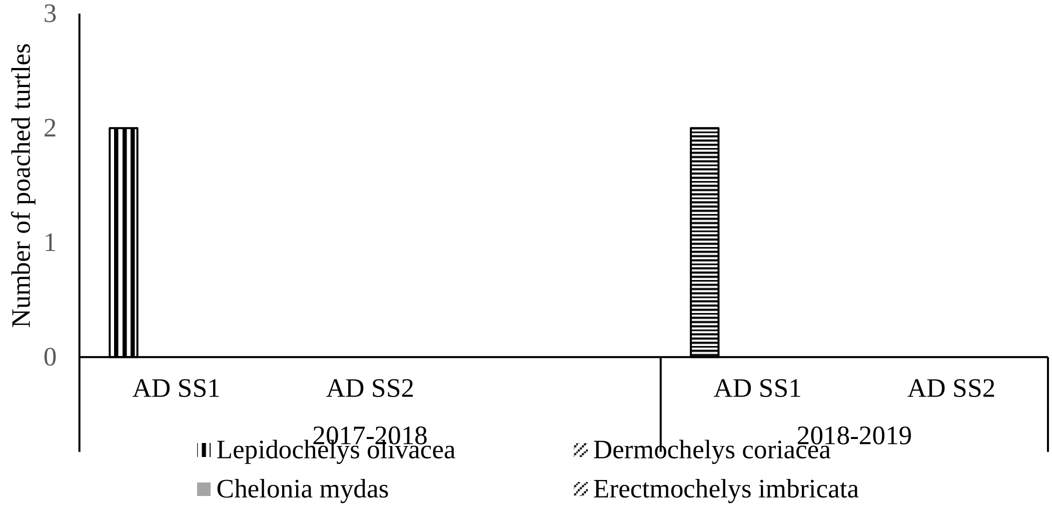

Figure 67: Total turtles and species poached at different sampling sites, 2017-2019 at Songor Ramsar site

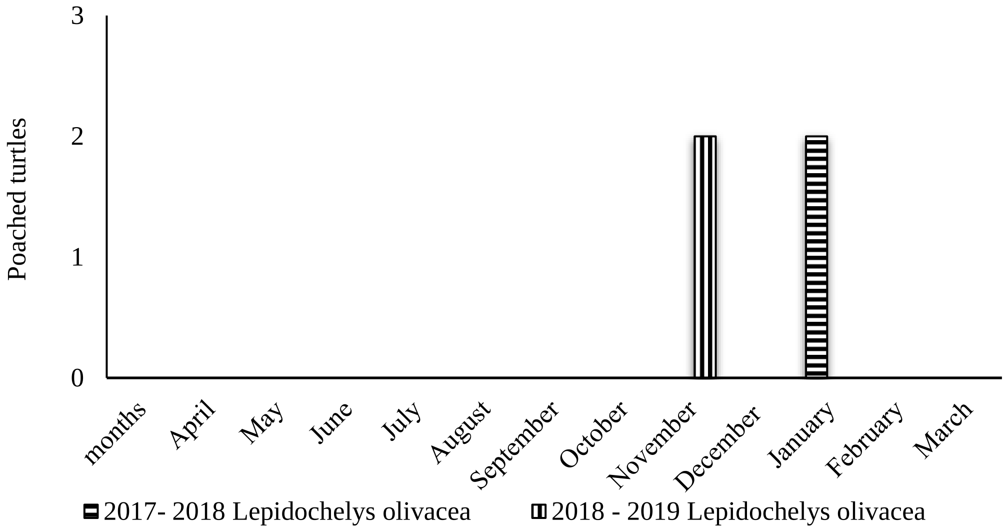

Figure 68: Distribution of turtle poaching activities, 2017 – 2019 at Songor Ramsar site

Turtle poaching activities were unevenly distributed within the sampling periods. In 2017 - 2018, poaching occurred in January 2018, whiles in 2018 - 2019 it was recorded in November 2018 as indicated in Figure 67.

Occurrence of Poached Turtles at the Keta Lagoon Complex Ramsar Site

A total of 61 poached turtles constituting 93.8% of total poached turtles were recorded during the sampling periods. This comprised of 9 *L. olivacea* and 52 *D. coriacea* as indicated in Figure 68.

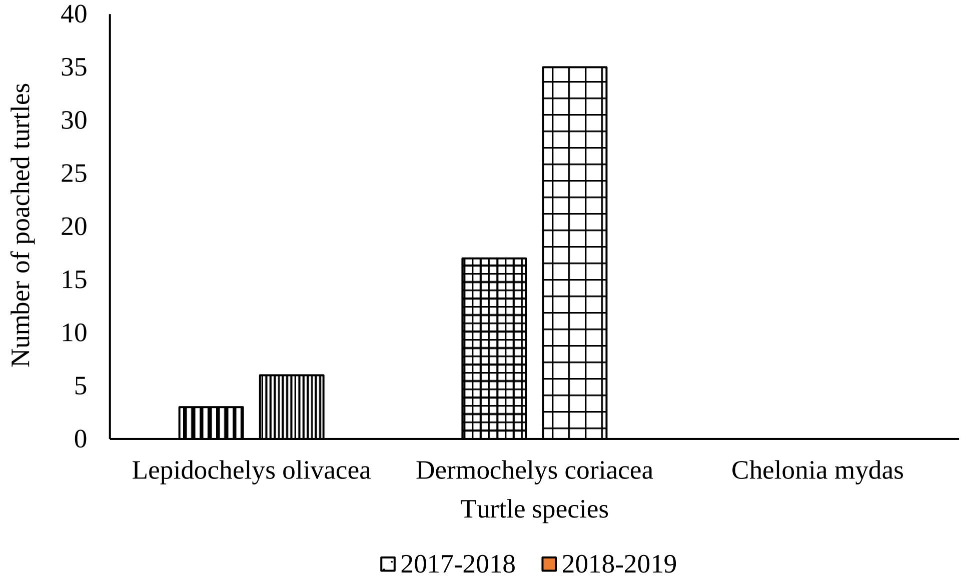

Figure 69: Total turtles and species poached, 2017 – 2019 at Keta Ramsar site

Though poaching varied between the sampling period it was not significant. During 2017 - 2018 sampling period 3 *L. olivacea* and 17 *D. coriacea* were poached. Out of these, 1 *L. olivacea* and 8 *D. coriacea* were poached in sampling site 1. One *D. coriacea* was poached in sampling site 2, whiles, 8 *D. coriacea* were poached in sampling site 3 (Figure 69). Six *L. olivacea* and 35 *D. coriacea* were poached in 2018 - 2019 periods. Five *L.*

olivacea and 8 *D. coriacea* were poached in sampling site 1. Fifteen *D. coriacea* were poached in sampling site 2. In sampling site 3, 1 *L. olivacea* and 8 L *D. coriacea* were poached. Four *D. coriacea* were poached in sampling site 4 (Figure 69).

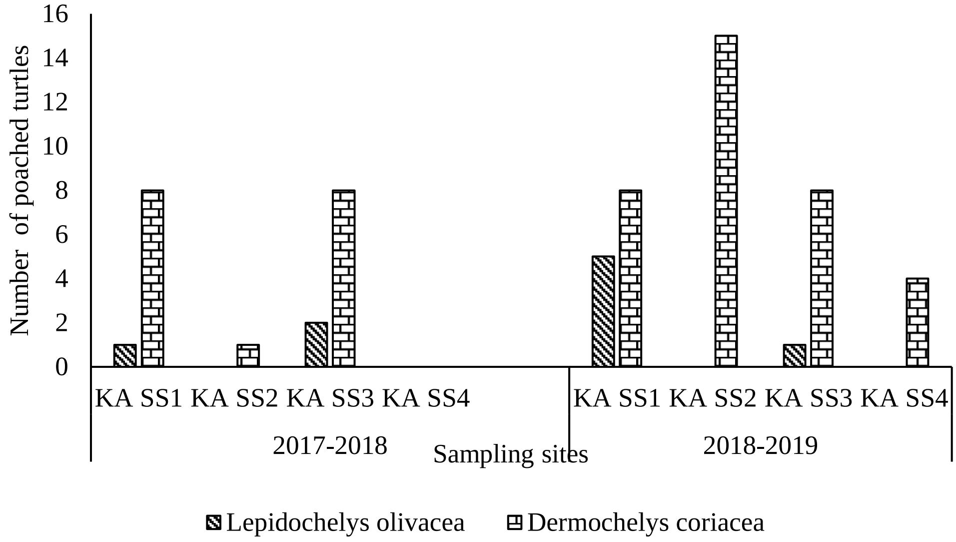

Figure 70: Total turtles and species poached at different sampling sites, 2017-2019 at Keta Ramsar site

The trend of turtle poaching within the sampling area is shown in Figure 70. Poaching of turtles occurred in June 2017 during the 2017 - 2018 sampling period. Poaching was later encountered in September 2017, October 2017, November 2017, December 2017 and January 2018. Poaching activities were concentrated between September 2017 and January 2018. November 2017 and December 2017 were the peak poaching periods (Figure 70).

Unevenly distributed poaching trend was exhibited during 2018 - 2019 sampling period. Poaching occurred in July 2018, October 2018 and reached a peak in December 2018. There was a dip in the activities in January 2019 to February 2019. Poaching within the period was concentrated between the October 2018 to February 2019 (Figure 70).

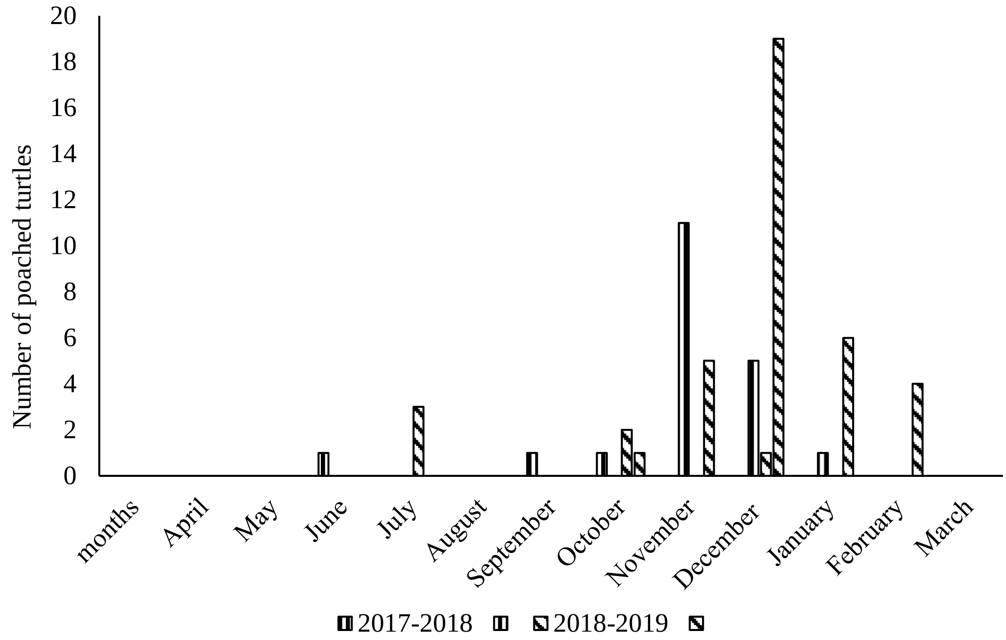

Figure 71: Distribution of turtle poaching activities, 2017 – 2019 at Keta Ramsar site

Shoreline Changes and Landforms at the Songor Ramsar Site

During 2017 - 2018 sampling period, a mean monthly erosion value between 2.40m and 23.92m was recorded at site 1 Appendix (4). A mean monthly accretion between 0.74 and 38.34m was recorded within sampling site 1 (Appendix 5). A mean erosion value of 37.66m was recorded at sampling site 1 (Appendix 4), whiles a mean accretion value of 47.56m occurred within the same sampling site (Appendix 5). A net accretion value of 9.9m was recorded at sampling site 1 during the sampling period. Erosion was high during October 2017 (7.46m, SD 12.11), December 2017 (23.92m, SD 26.17) and February 2018 (13.06m, SD 15.89) (Appendix 4 and Figure 71). Corresponding sand dunes created by excessive waves were high in July (0.52m), August 2017 (0.67m), February 2018 (0.48m) and March 2018 (0.42m) (Appendix 6 and

Figure 73). The highest erosion recorded at the sampling site 1 occurred in December 2017 (67.60m) along the beach of Azizanya thus influencing the increase in the monthly mean erosion of 23.92m (Figure 71 and Appendix 4). Accretion values recorded were high in October 2017 (11.20m, SD 22.03), November 2017 (38.34m, SD 38.92) and March 2018 (10.72m, SD 8.21) (Appendix 5). Sand dune heights recorded were observed to be medium to low during the same period: August 2017 (0.67m), November 2017 (0.33m) and March 2018 (0.42m) (Appendix 6 and Figure 73).

During the sampling period a mean monthly erosion values between 0.36 and 15.23m occurred at site 2 (Appendix 7 and Figure 72) whilst a mean monthly accretion value between 2.0 and 9.73m was recorded (Appendix 18). A mean erosion value of 19.25m was recorded at the site (Appendix 7) whilst a mean accretion value of 18.18m was recorded for the same sampling site (Appendix 8). A marginal net erosion of 1.07m was recorded within sampling site 2. Erosion values recorded were high during the periods of October 2017 (15.23m), November 2017 (14.46m) and February 2018 (9.60m) (Appendix 7 and Figure 72). Accretion was high in August 2017 (10.73m), November 2017 (9.73m) and January 2018 (9.50m) (Appendix 8 and Figure 72). Sand dunes values recorded at sampling site 2 were generally low, less than 1m was recorded as monthly mean and 2m as mean value at the site (Appendix 9).

During 2018 - 2019 sampling period, a mean monthly erosion value between 0.24 and 40.0m was recorded at sampling site 1 (Appendix 10) whilst a mean monthly accretion value ranging between 0.4 and 58.2m occurred within the same sampling site (Appendix 11). A mean erosion value of 39.84m was recorded at sampling site 1 whilst a mean accretion of 44.93m occurred within the same site (Appendices 10 and 11). A net accretion of 5.09m occurred during the sampling period. Monthly mean erosion value was high in February 40.4m (SD 66.04) Appendix 10 and Figure 76). This was due to high erosion that occurred on the shoreline of Azizanya (152.0m). A high mean accretion value was recorded in January, 58.2m (SD 68.07). This value was influenced by a high beach accretion recorded in January 2019 at Azizanya (169.0m) (Appendices 11 and Figure 74). Dunes created as a result of excessive waves and erosion were high in the months of August 2018 (0.90m), September 2018 (0.66m) and October 2018 (0.83m) (Appendix 12 and Figure 74). A mean dune height of 2.97m was recorded at the sampling site (Appendix 12).

Within sampling site 2 a mean monthly erosion value between 0.06 and 84.0m was recorded during 2018 - 2019 sampling period (Appendix 13), whilst a mean monthly accretion value that range between 1.96 and 119.8m occurred within the same period (Appendix 14). A net accretion value of 21.2m was recorded for the sampling site. Erosion values recorded were high in February 2019 along the beach of Totope (166m). This value influenced a high mean erosion recorded in February 2019, 84.0m (SD 71. 02). Accretion along the beach was exceptionally high in sample site 2 during the sampling period in January 2019, 81.0m (SD 93.50) and February 2019, 119.8m (SD 86.54) (Appendix 14 and Figure 75). A relatively low and stable mean sand dune height between 0.18 and 0.55m was recorded within the sampling site. A mean dune height of 1.05m occurred at the sampling site (Appendix 15 and figure 76).

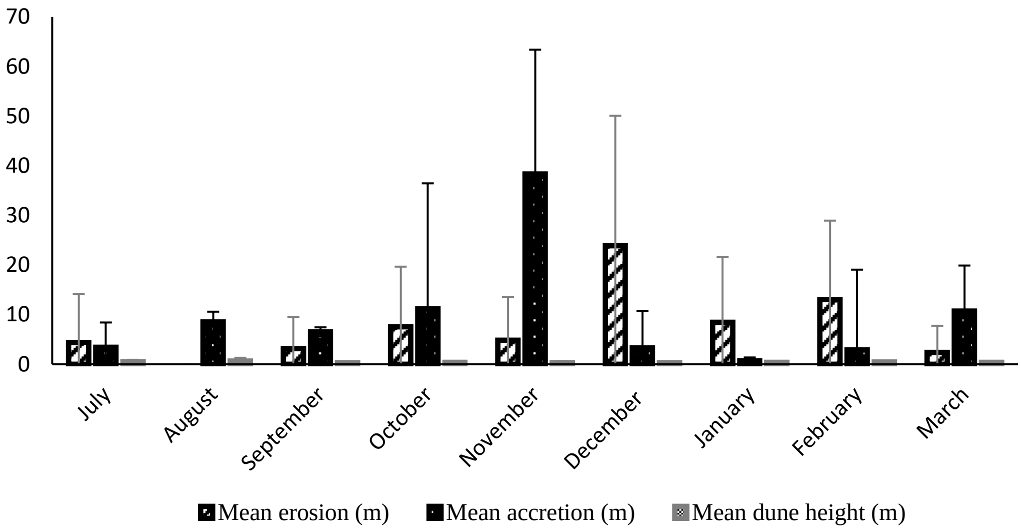

Figure 72: Mean erosion, accretion and dune heights recorded within site 1 (Ad SS 1) during 2017 - 2018 sampling period at Songor Ramsar site

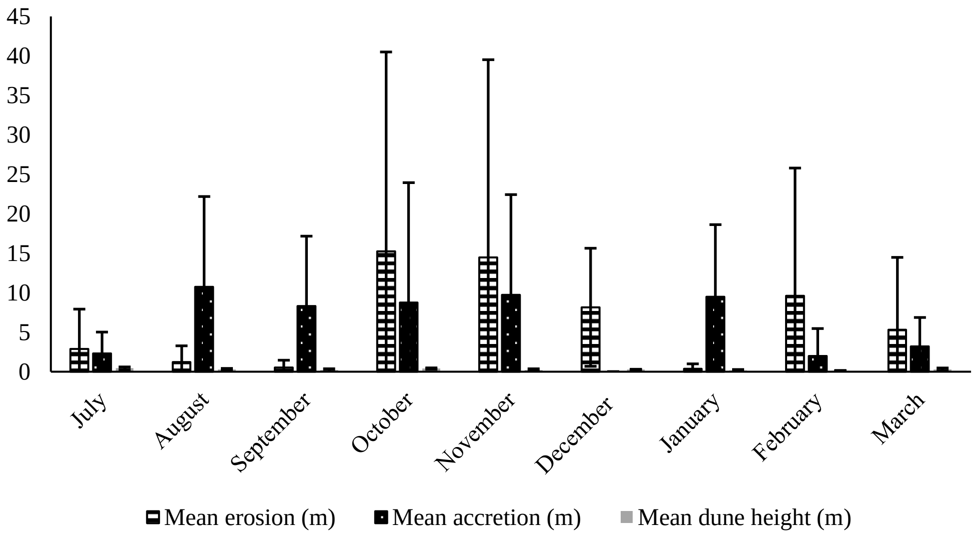

Figure 73: Mean erosion, accretion and dune heights recorded within site 2 (Ad SS 2) during 2017 - 2018 sampling period at Songor Ramsar site

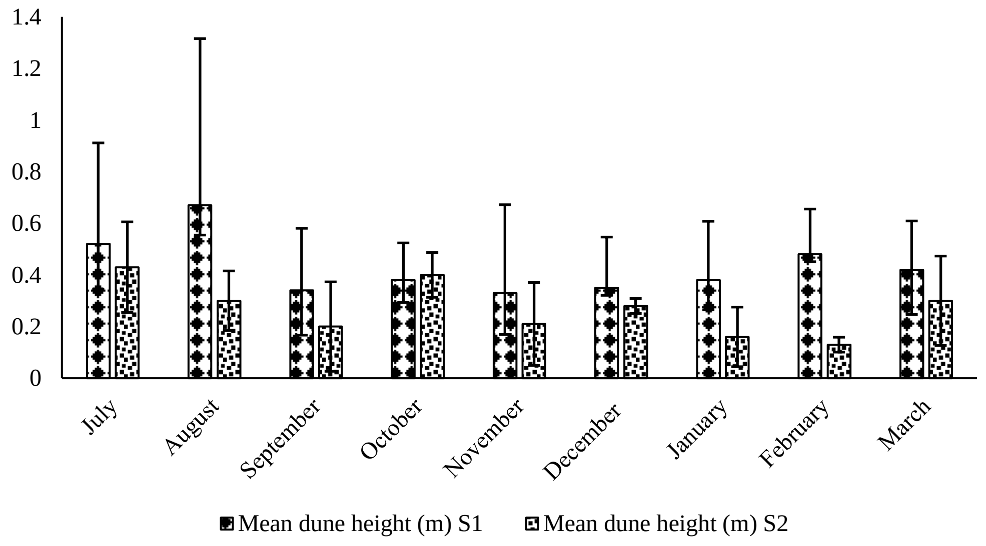

Figure 74: Mean dune height recorded at sampling site 1 and 2 during 2017 - 2018 sampling period at Songor Ramsar site

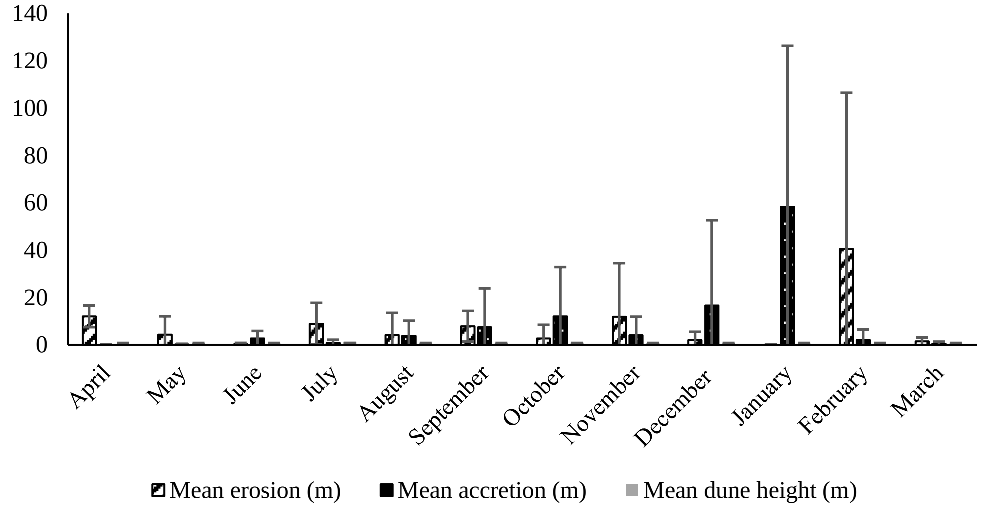

Figure 75: Mean erosion, accretion and dune heights within sampling site 1 during 2018 - 2019 sampling period at Songor Ramsar site

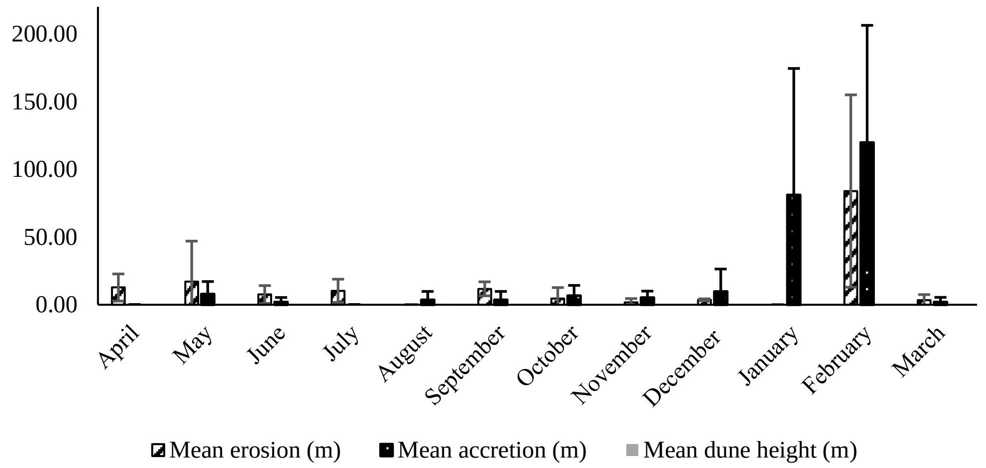

Figure 76: Mean erosion, accretion and dune heights within sampling site 2 during 2018 - 2019 sampling period at Songor Ramsar site

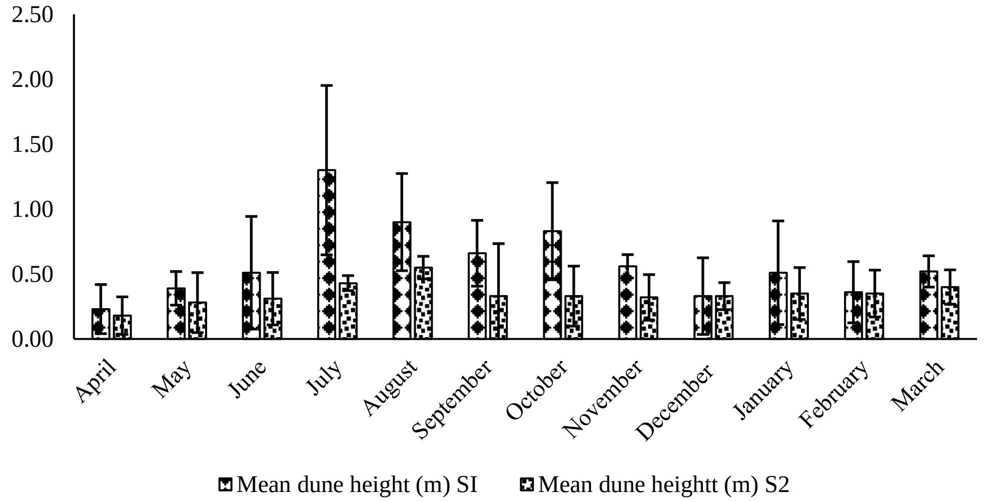

Figure 77: Mean dune height between sampling site 1 and 2 during 2018 - 2019 sampling period at Songor Ramsar site

Shoreline Changes and Landforms at the Keta Lagoon Complex Ramsar Sites

The mean monthly erosion recorded during 2017 - 2018 sampling period ranges between 1.2 and 20.52m at sampling site 1 (Appendix 16). The mean monthly accretion value at the same sampling site ranges between 2.0 and 22.02m (Appendix 17). A mean erosion value of 36.74m was recorded at the sampling site (Appendix 16) whilst a mean accretion value of 52.59m occurred (Appendix 17). A net mean accretion value of 15.85m was recorded at the sampling site. Monthly mean erosion values recorded were high in October 2017 (18.66m) and February 2018 (20.52m) (Appendix 16 and Figure 77). Mean monthly accretion values were high in August 2017 (15.56m) and March (22.02m) (Appendix 17 and Figure 77). Mean dunes values ranges between 0.4 and 0. 89m.occurred within the sampling site (Appendix 18). The highest sand dunes occurred in February, 0.89m (SD 0.48). Mean dune height value of 2.13m was recorded at the sampling site (Appendix 18 and figure 81).

A mean monthly erosion value between 11.8 and 2 4.6m was recorded at sampling site 2 and a mean erosion value of 15.93m occurred within the sampling site (Appendix 19). A mean monthly accretion value ranging between 5.4 and 21.45m was recorded at the sampling site and a mean accretion value of 20.55 was recorded at the same sampling site (Appendix 20). A net mean accretion value of 4.62m was recorded at the site. Mean monthly erosion values were high in February (19.8m) and March (24.6m) (Appendix 19 and Figure 78) whilst mean monthly accretion values recorded were high in August (17.5m) and January (21.45m) (Appendix 20 and Figure 78). A monthly mean dune ranging between 0.10 and 0.77m was recorded during the sampling period.

A mean dune value of 0.67m was recorded at the site. Generally, the shoreline was relatively stable but sand dunes were high in July (0.77m) and November (0.40m) (Appendix 21 and Figure 78).

Within sampling site 3, a mean monthly erosion value that ranges between 3.95 and 43.45m was recorded. A mean erosion value of 16.6 occurred within the sampling site (Appendix 22). A mean monthly accretion value ranging between 4.95 and 30.95m was recorded whilst the mean accretion at the site was 24.21m (Appendix 23). A mean net accretion value of 8.05m occurred during sampling period. Erosion along the shoreline was relatively low but peaked in the months of January (12.75m) and March (43.45m) (Appendix 22). Accretion values were high in October (30.95m) and March (26.04m) (Appendix 23, Figure 79). Mean dune value recorded during the period ranges between 0.10 and 0.45m. A mean dune value of 0.75m was recorded at the sampling site. Moderate mean high dunes occurred in July 2017 (0.4m) and January 2018 (0.45m) (Appendix 34 and Figure 81).

Within sampling site 4 a mean monthly erosion value ranging between 0.4 and 12.10m and a mean erosion value of 10.22m occurred within the site (Appendix 25). A mean monthly accretion values ranges between 2.0 and 18.85m and a mean accretion value of 13.53m was recorded at the sampling site (Appendix 26). A moderate mean net accretion of 3.31m occurred within the sampling site. Mean monthly erosion values were moderately high in November 2017 (12.10m) and February 2018 (11.5m) (Appendix 25 and Figure 80). Mean monthly accretion values were high in February 2017 (11.7m) and January 2018 (18.85m) (Appendix 26 and Figure 81). Monthly mean dune values recorded ranges between 0.15m and 0.38m and a mean dune height of 0.63m occurred within the sampling site (Appendix 27 and Figure 81).

During 2018 - 2019 sampling period a mean monthly erosion value ranging between 0.2 and 9.92m and a mean erosion value of 17.03m was recorded within sampling site 1 (Appendix 28). A mean monthly accretion values ranging between 1.2 and 31.8m and a mean accretion value of 23.88m was recorded at the same sampling site (Appendix 28). A net mean accretion value of 6.85m occurred within the sampling site. Mean monthly erosion recorded were high in the months of April 2018 (17.03m) and September 2018 (9.92m) (Appendix 28 and Figure 82). Mean monthly accretion values recorded were equally high in October 2018 (6.2m) and February 2019 (31.8m) (Appendix 29 and Figure 82). Mean monthly dune height recorded ranges between 0.2 and 0.56m and a mean dune height of 1.75m occurred within the sampling area. Mean dunes heights were moderately high in April 2018 (0.56) and February 2019 (0.46m) (Appendix 30 and Figure 86).

Within sampling site 2, a mean monthly erosion value that ranges between 1.2 and 8.25m and a mean erosion value of 8.63m was recorded within the sampling area (Appendix 31). A mean monthly accretion values ranging between 0.5 and 19.85m and a mean accretion value of 7.91m occurred within the sampling site (Appendix 32). A marginal net mean erosion value of 0.71m was recorded during the sampling period. Mean monthly erosion values were high in October 2018 (12.2m) and March 2019 (9.0m) (Appendix 31 and Figure 83). Mean monthly accretion values recorded were high in January 2019 (14.25m) and March 2019 (19.85m) (Appendix 32 and Figure 83). A mean sand dune height values recorded within the sampling site ranges between 0.5 and

1.65m and a mean sand dune height of 1.7m occurred within the sampling site (Appendix 33). Sand dune values were high in May 2018 (1.65m) and June (1.53m) (Appendix 33 and Figure 86).

Within sampling site 3, a mean monthly erosion value ranging between 3.0 and 91.25m and a mean erosion of 22.22m was recorded within the sampling site (Appendix 34). A mean monthly accretion value that ranges between 0.5 and 93.69m and a mean accretion of 33.22m occurred within the sampling site (Appendix 35). A mean net accretion value of 10.98m was recorded within the sampling site. Mean monthly erosion values recorded were high in April 2018 (17.65m) and February 2019 (91.25m) (Appendix 34 and Figure 84). Mean monthly accretion values recorded were high in September 2018 (15.72m) and January 2019 (93.69m) (Appendix 35 and Figure 84). Mean monthly sand dunes values recorded ranges between 0.23 and 0.50m and a mean sand dune height of 0.75m occurred within the sampling site (Appendix 36). Mean monthly sand dune values were high in June 2018 (0.50m) and March 2019 (0.45m) (Appendix 36 and Figure 86).

During the sampling period, a mean monthly erosion value between 2.66 and 20. 20m and a mean erosion of 16.59m was recorded within sampling site 4 (Appendix 37). A mean monthly accretion value ranging between 1.5 and 22.3m and a mean accretion of 18.66m was recorded during the sampling period (Appendix 38). A marginal mean net accretion value 2.07m occurred within the sampling site. Mean monthly erosion values recorded were high in August 2018 (8.45m) and September 2018 (20.20m) (Appendix 37 and Figure 85). Mean monthly accretion recorded within the site were high in August 2018 (23.4m) and October 2018 (22.30m) (Appendix 38 and Figure 90). Mean monthly sand dune height values ranges between 0.15 and 0.40m and a mean dune height of 0.60m occurred within the site (Appendix 39 and Figure 86). Mean sand dunes recorded were moderately high in August 2018 (0.43m) and September 2018 (0.45) (Appendix 39 and Figure 86).

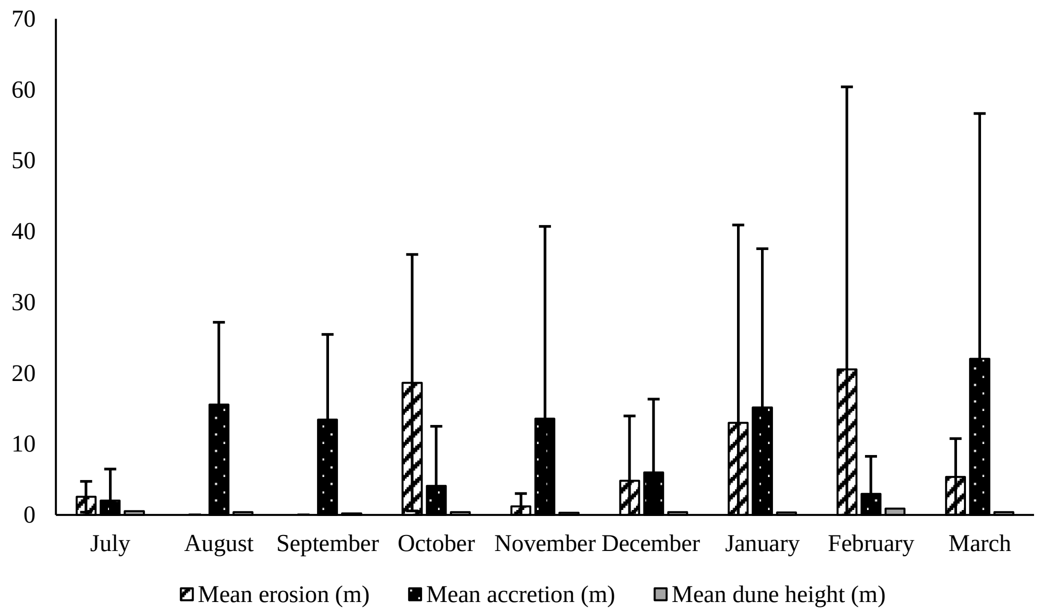

Figure 78: Mean erosion, accretion and dune heights within sampling site 1 during 2017 - 2018 sampling period at Keta Ramsar site

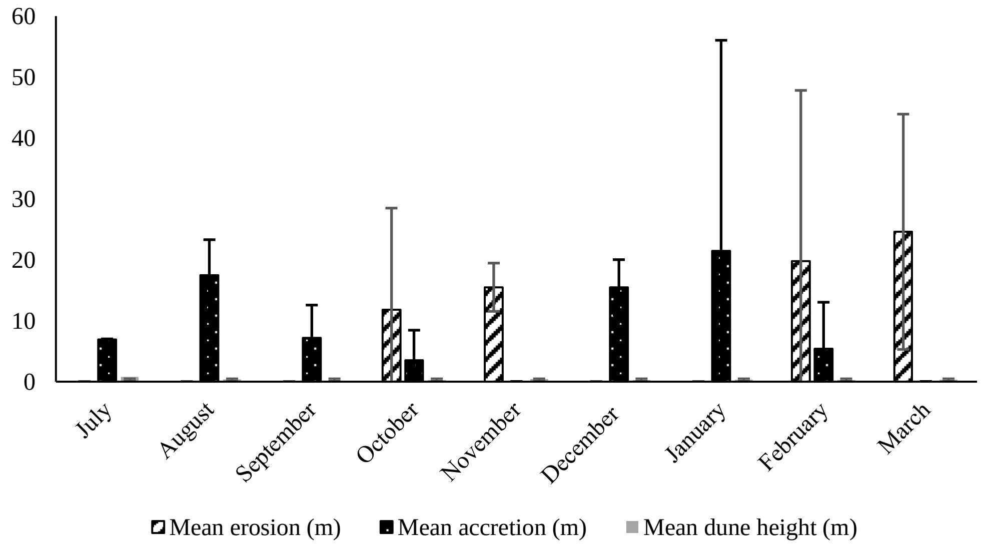

Figure 79: Mean erosion, accretion and dune heights within sampling site 2 during 2017 - 2018 sampling period at Keta Ramsar site

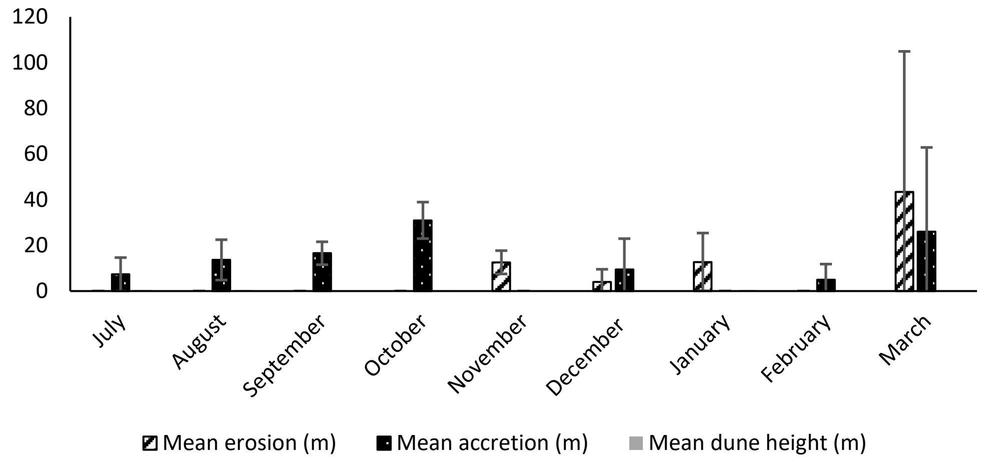

Figure 80: Mean erosion, accretion and dune heights within sampling site 3 during 2017 - 2018 Sampling period at Keta Ramsar site

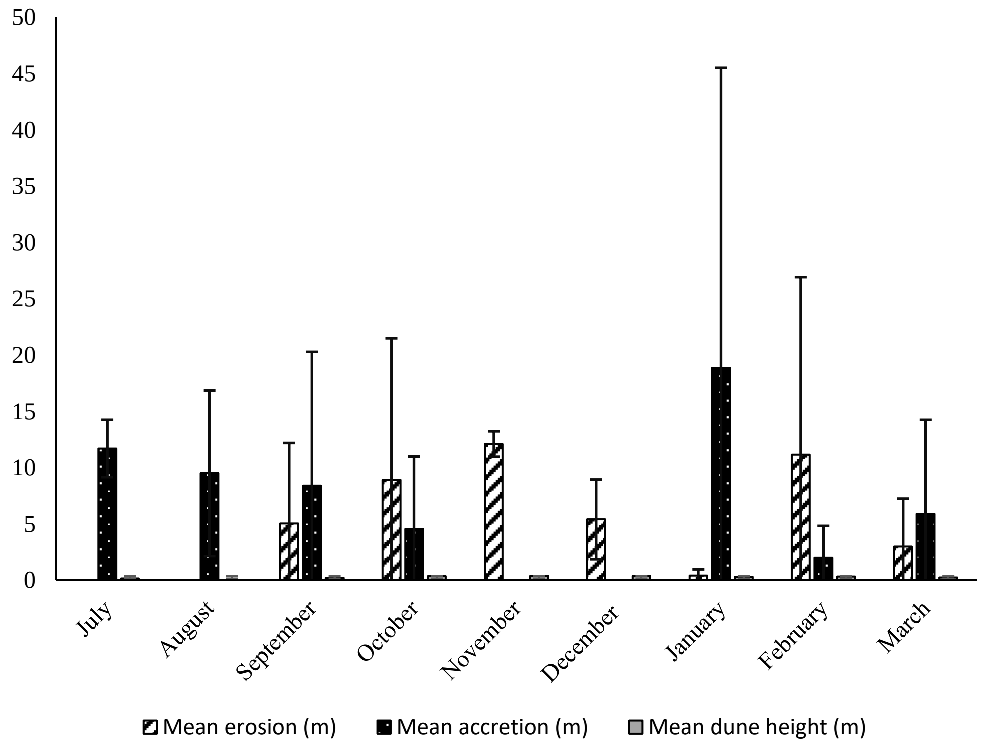

Figure 81: Mean erosion, accretion and dune heights within sampling site 4 during 2017 – 2018 sampling period at Keta Ramsar site

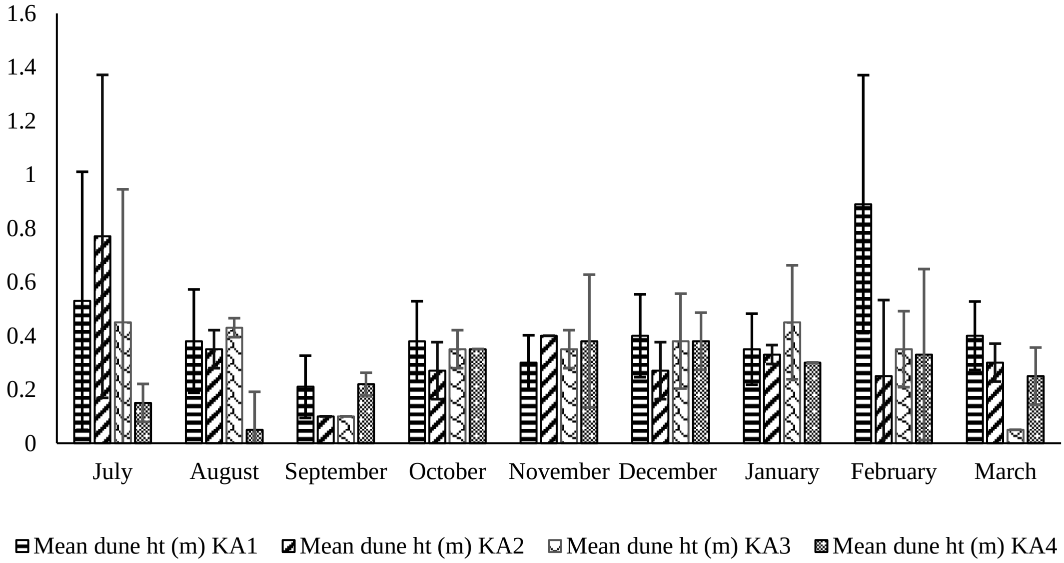

Figure 82: Mean sand dune height between sampling site 1, 2, 3 and 4 during 2017 - 2018 sampling period at Keta Ramsar site

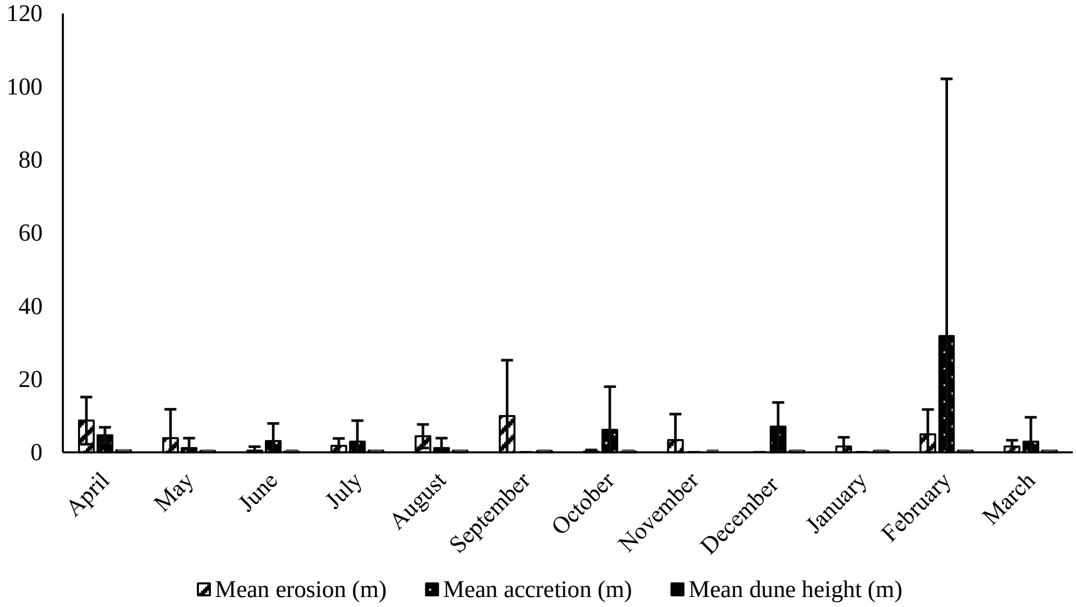

Figure 83: Mean erosion, accretion and dune heights within sampling site 1 during 2018 - 2019 sampling period at Keta Ramsar site

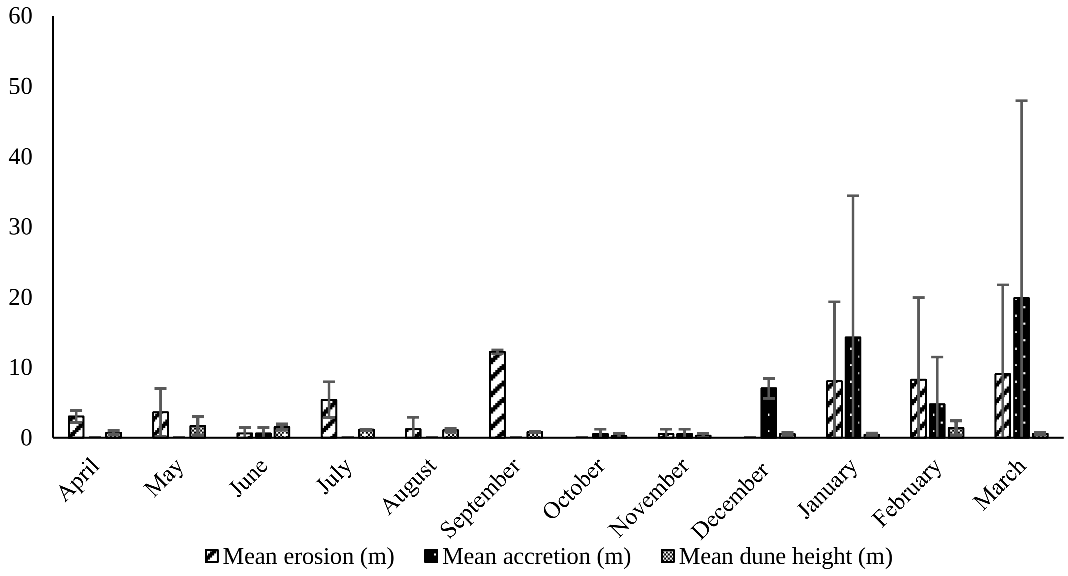

Figure 84: Mean erosion, accretion and dune heights within sampling site 2 during 2018 - 2019 sampling period at Keta Ramsar site

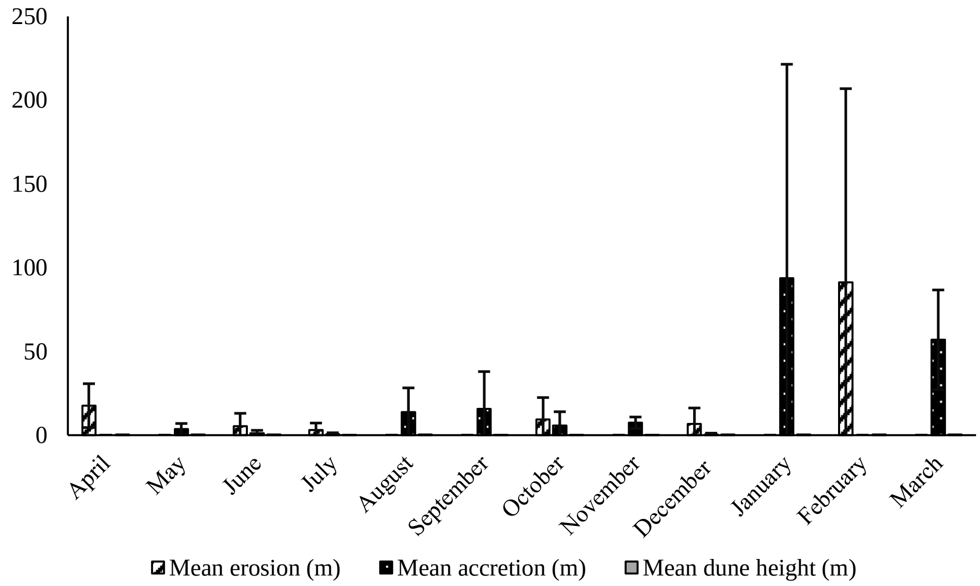

Figure 85: Mean erosion, accretion and dune heights within sampling site 3 during 2018 - 2019 sampling period at Keta Ramsar site

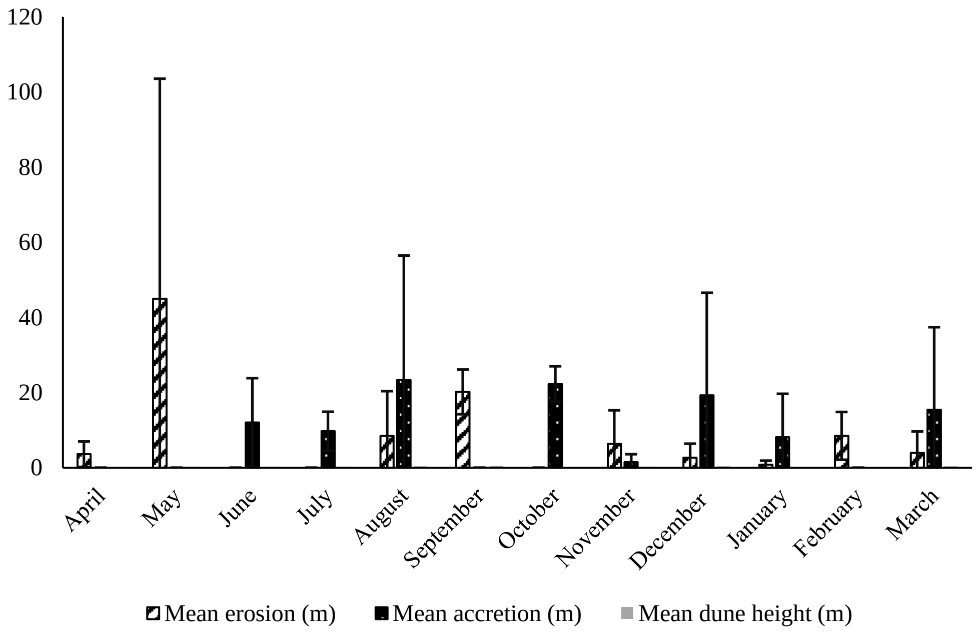

Figure 86: Mean erosion, accretion and dune heights within sampling site 4 during 2018 - 2019 sampling period at Keta Ramsar site

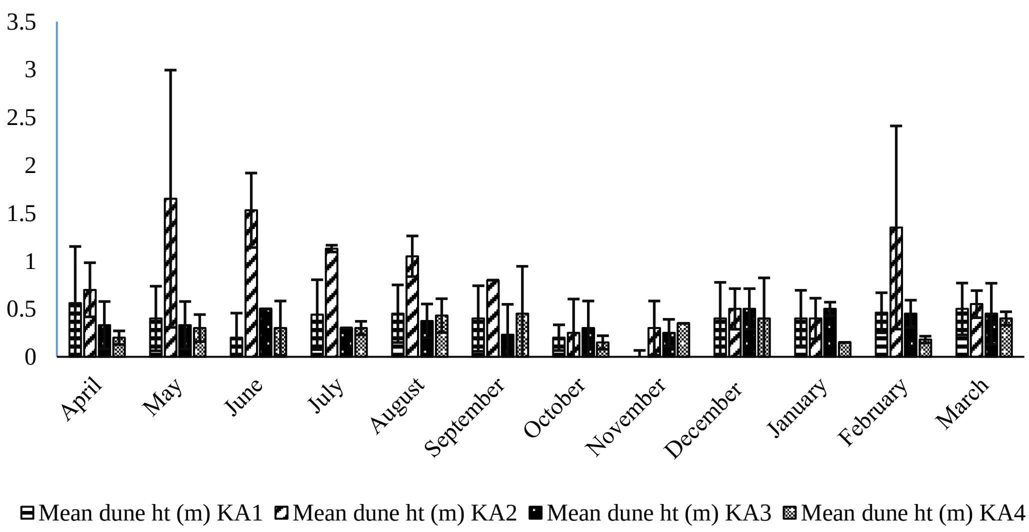

Figure 87: Mean sand dune height between sampling site 1, 2, 3 and 4 during 2018 - 2019 sampling period at Keta Ramsar site

Shoreline Changes and Occurrence of Turtle Nesting Activities in the Songor Ramsar Site

Sand dune and nesting turtles observed at Songor Ramsar Site

The result indicated that *L. olivacea* turtle was encountered when average sand dune recorded on the shoreline was low in September 2017 (0.54m) (Figure 87). Two nesting D. *coriacea* were observed when dune height was low in in December 2018 (0.66m) (Figure 87). No nesting or stranding turtles were encountered during periods of high sand dunes; 0.67 and 1.73m (Figure 87 and 88).

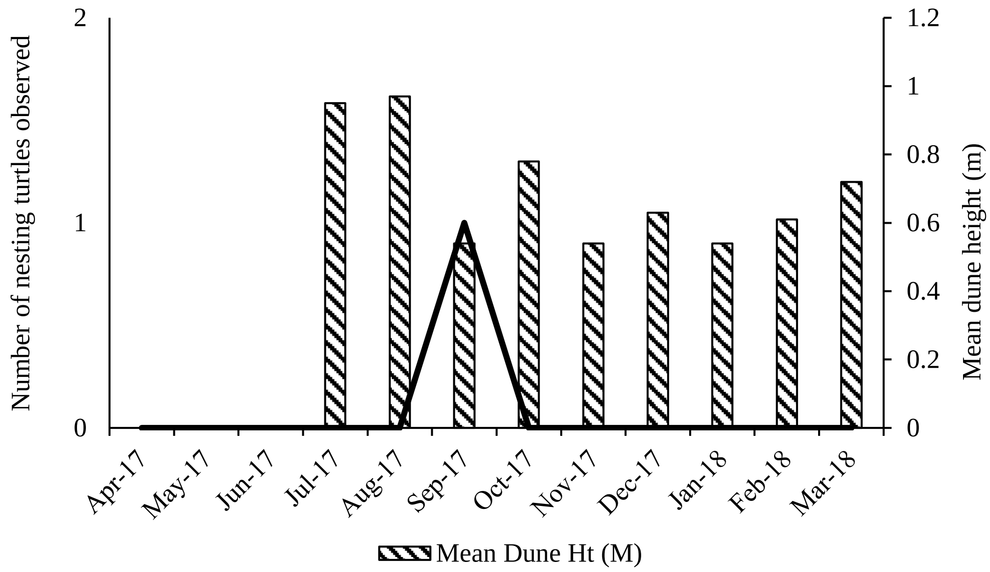

Figure 88: Mean dune height and nesting turtle observed on the beach during 2017 – 2018 Songor Ramsar site

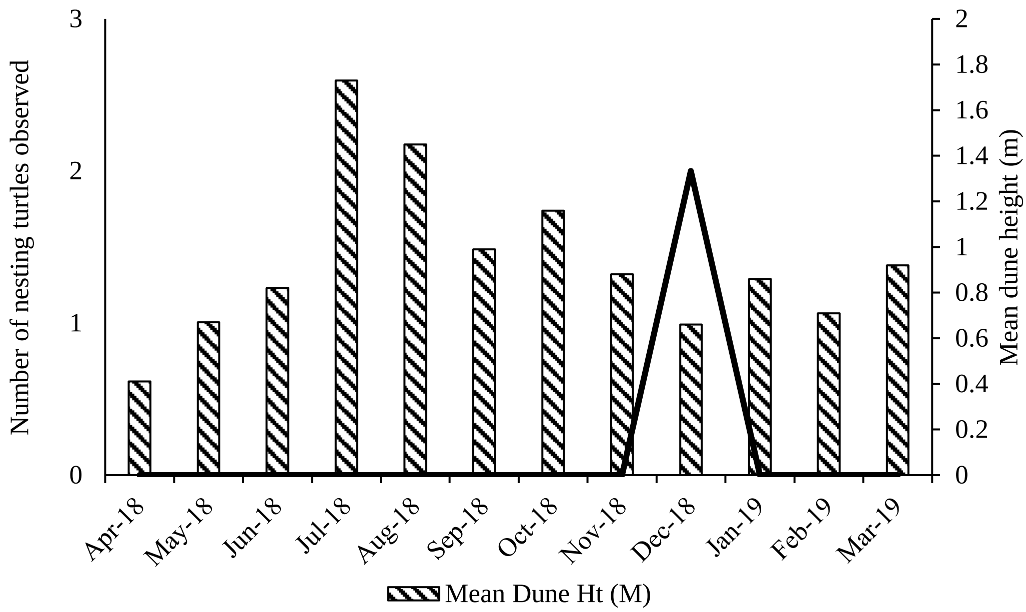

Figure 89: Mean dune height and nesting turtles observed on the beach during 2018 – 2019 at Songor Ramsar site

Sand dune and turtle nesting activities observed at Songor Ramsar Site

Turtle nesting activities recorded during the sampling periods, were equally high when sand dunes on the shoreline were low, nest crawls and nest spots recorded were high whiles non-nesting crawls were low (Figure 89). High nesting activities occurred in November 2017 and December 2017. Correspondingly, low dunes were recorded during the sampling periods, September 2017 and November 2017 to January 2018. The period also coincided with the emerging and peak nesting seasonal activities of *L. olivacea* and *D. coriacea* (Figures 89). Mean dune height displayed a negative correlation with nest crawls (r = - 0.11), non-nest crawls (r = - 0.21) and nest spots (r = - 0.31) (Appendix 50).

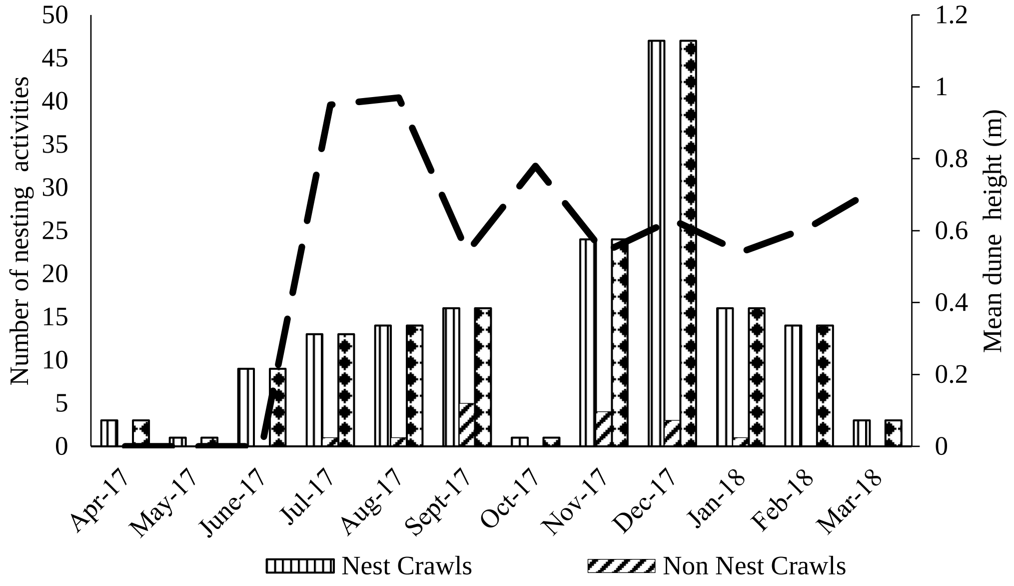

Figure 90: Dune height and occurrence of turtle nesting activities observed in 2017 - 2018 at Songor Ramsar site

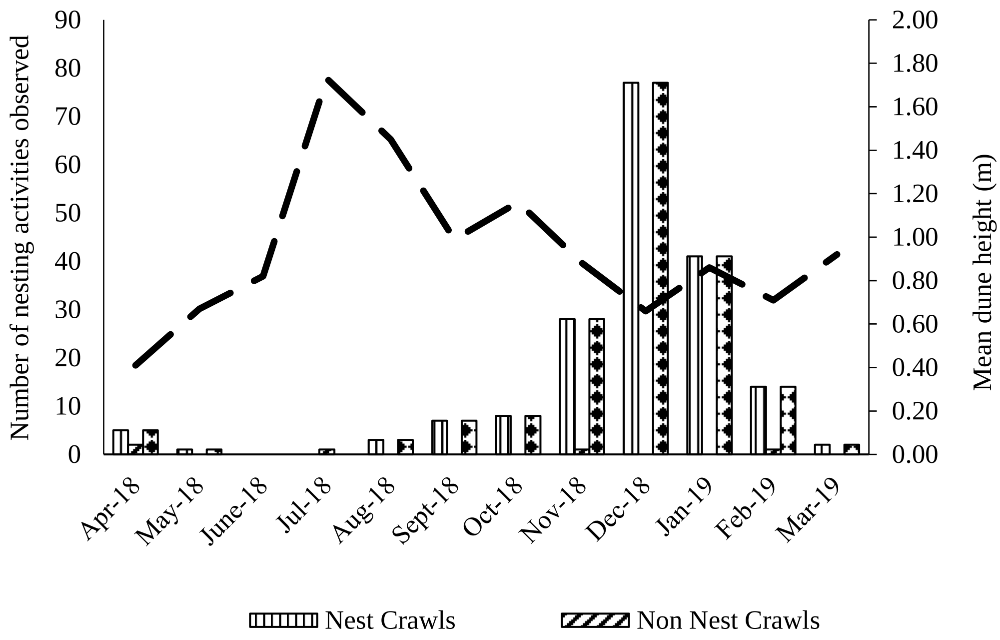

Figure 91: Dune height and turtle nesting activities observed in 2018 – 2019 at Songr Ramsar site

Erosion, accretion and turtle nesting activities at Songr Ramsar site

Periods of high erosion were associated with uneven shoreline and high dunes. Equally, the number of nesting and stranding turtles recorded were low when mean monthly erosion rates recorded in September 2017 and December 2017 were high. October 2017, December 2017, February 2018 and March 2018 were characterised by high erosion and low number of turtle nesting activities were recorded during the period. Exceptional occurrence was observed in November 2017 and December 2017, when probably *D. coriacea* were able to locate suitable nesting beach during the high erosion periods. Seven non-nesting crawls were recorded during the same period. It was observed that, the turtles could not identify suitable nesting beach (Figure 91). Marginal erosion rates were recorded during the 2018 - 2019 sampling period except February 2019, when erosion value recorded was high, 124.4m. These periods were characterised by low turtle nesting activities. Erosion values recorded were low in November 2018; 13.46, December 2018; 5.66m and January, 0.00m and these periods were characterised by high turtle nesting activities (Figure 92). There was a negative correlation between mean erosion and nest crawls (r = - 0.11), nest spots (r = - 0.11) whiles a positive correlation was displayed between mean erosion and non-nest crawls (r = 0. 41) (Appendix 51).

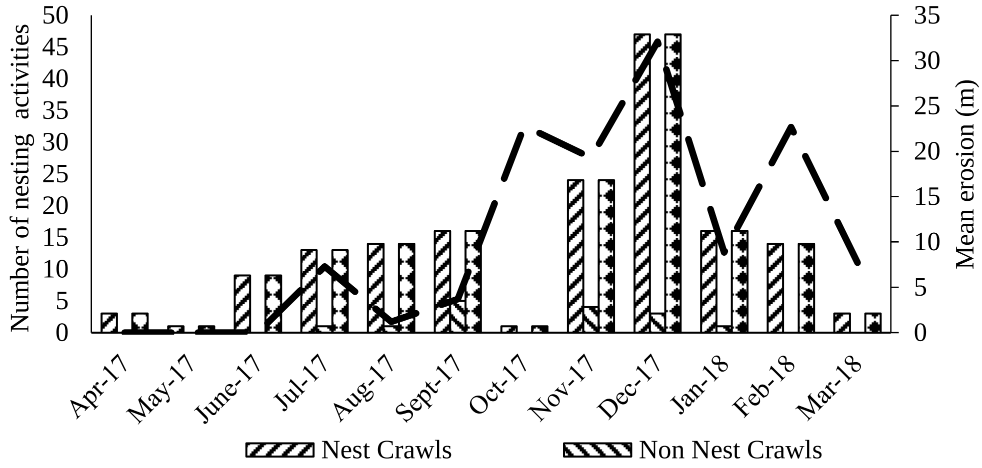

Figure 92: Erosion and occurrence of turtle nesting activities in 2017 - 2018 period at Songor Ramsar site

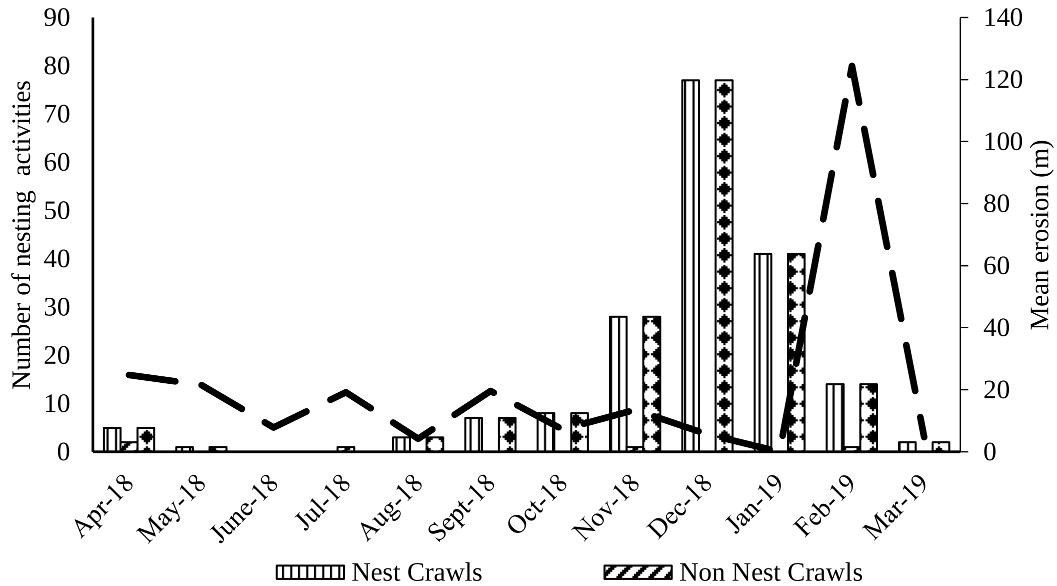

Figure 93: Erosion and occurrence of turtle nesting activities in 2018 - 2019 period Songor Ramsar site

Accretion was observed to be a profound seasonal beach nourishment process that lowers the height of dunes and enhance the accumulation of natural sand on the beach. Accretion varied over the period. Live turtles were encountered in September 2017 and December 2018 when average accretion was 14.85m and 26.26m respectively. High accretion in August 2017, October 2017, November 2017, January 2018 and March 2018 periods were associated with high turtle nesting activities (Figure 93). The shoreline generally accreted marginally during the 2018 - 2019 sampling period. Between January 2019 and February 2019, exceptional high average accretion of 139.2m and 121.8m were recorded. These periods were characterised by high turtle nesting activities (Figure 94).

Within the sampling area, October 2017 was generally observed to be characterised by low turtle nesting activities even though the shoreline was adequately conducive. The period marked the nesting transition period between *L. olivacea* and *D. coriacea*. This was observed to signify a dip in nesting activities of *L. olivacea* and the onset of nesting period of *D. coriacea*. There was a positive correlation between nest crawls (r = 0.37), nest spots (r = 0.37) whiles a negative correlation occurred between non-nest crawls (r = - 0.34) (Appendix 52)

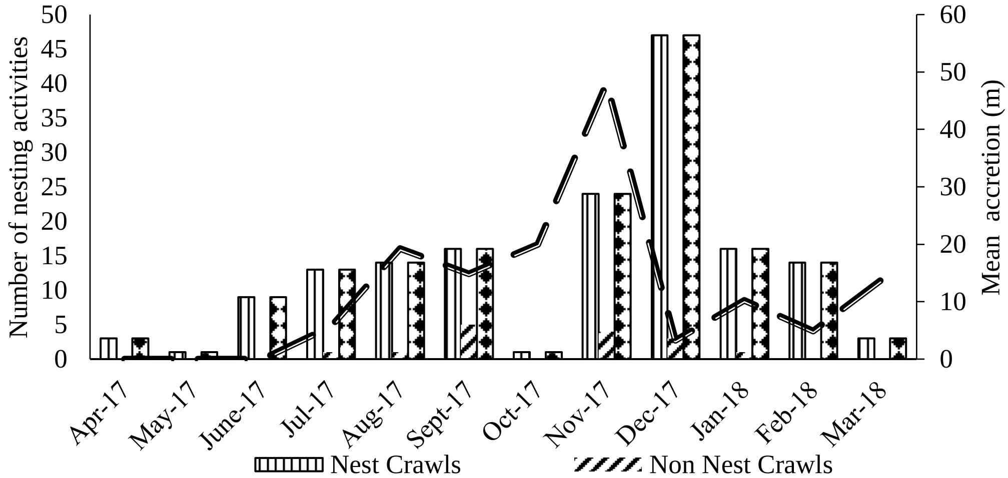

Figure 94: Accretion and occurrence of turtle nesting activities in 2017 - 2018 period Songor Ramsar site

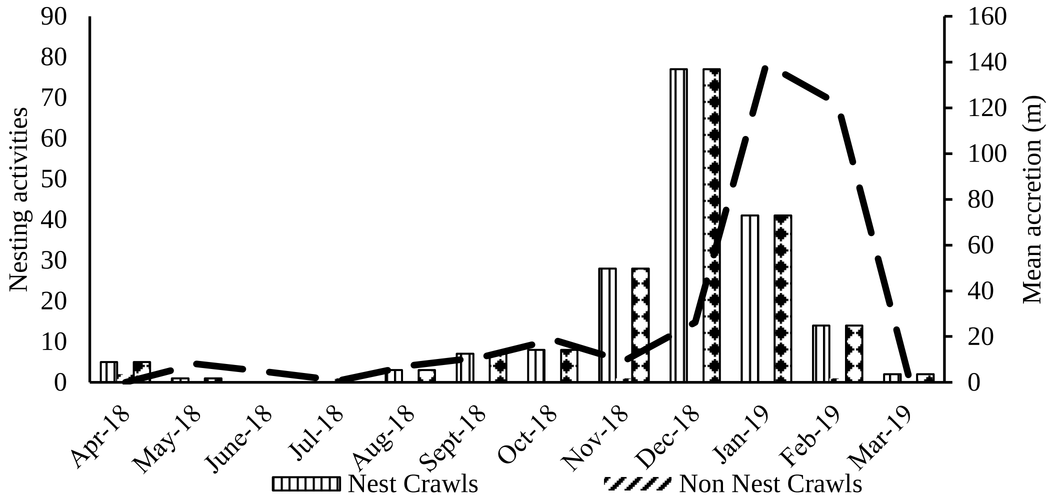

Figure 95: Accretion and occurrence of turtle nesting activities in 2018 - 2019 period. Songor Ramsar site

Shoreline Changes and Occurrence of Turtle Nesting Activities in the Keta Lagoon Complex Ramsar Site (KLCRS)

Sand dune and turtles observed at Keta Ramsar site

The mean sand dune heights recorded during 2017 - 2018 sampling period indicated a relatively high but stable shoreline at the sampling area, 1.02m. A stable sand dune height between 1.35 and 1.43m was recorded from October 2017 to January 2018 and three live turtles were encountered during the period (Figure 95). During 2018 - 2019 sampling period, relative low sand dunes between 0.90 and 1.45m characterised the beach from October 2018 to January 2019 and this period was associated with live turtles (Figure 96).

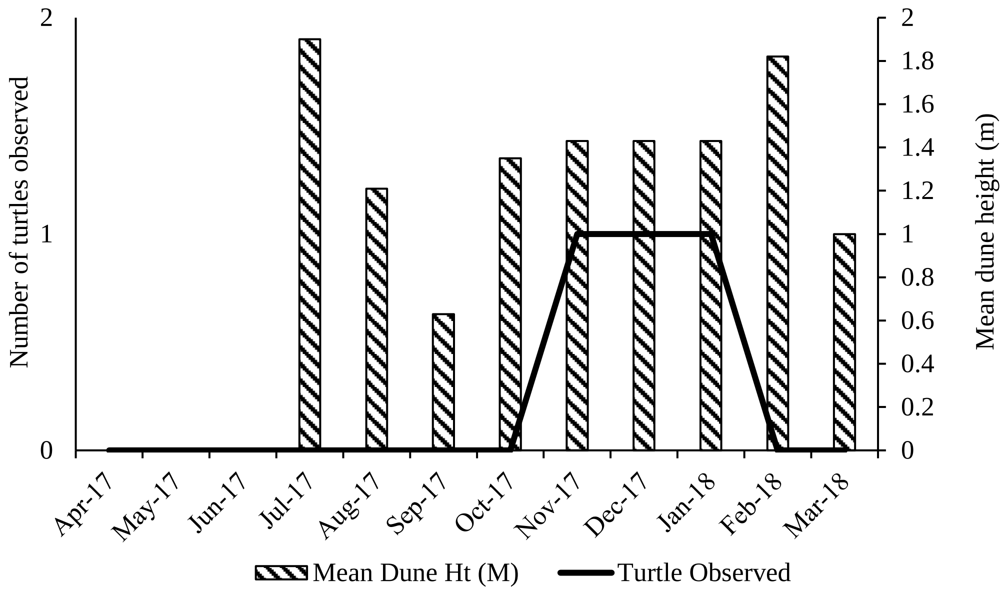

Figure 96: Mean dune height and number of nesting turtles observed on the beach during 2017 – 2018 at Keta Ramsar site

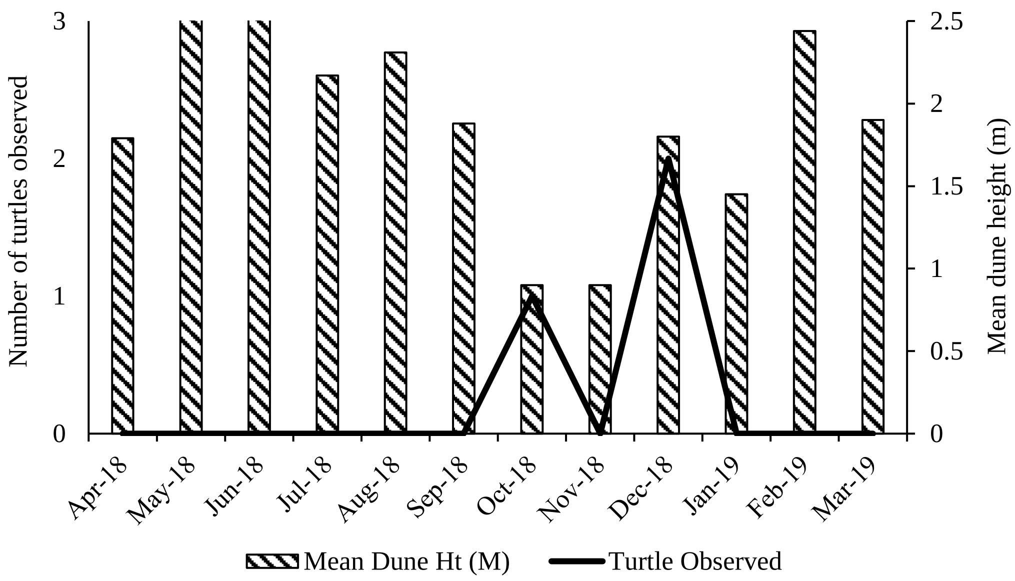

Figure 97: Mean dune height and number of nesting turtle observed on the beach during 2018 – 2019 at Keta Ramsar site.

Sand dune and turtle nesting activities at Keta Ramsar site

The relatively stable shoreline within the sampling area was characterised by evenly distributed nesting activities that steadily peaked from October 2017 to January 2018 during the 2017 - 2018 sampling period (Figure 97). High sand dunes occurred on the shoreline from April 2018 to September 2018; 1.79 and 2.68m during the 2018 - 2019 sampling period. This period was associated with low turtle nesting activities except July, 2018 that recorded moderate nesting activities (Figure 97). Between October 2018 and February 2019 relative low sand dune on the shoreline; 0.90 and 2.44m was marked with relatively high turtle nesting activities (Figure 98).

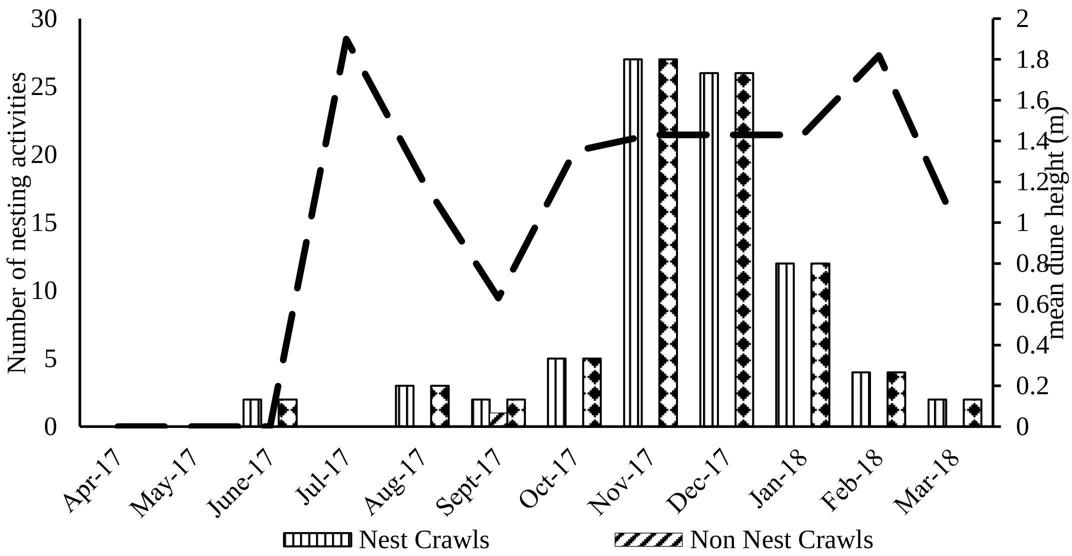

Figure 98: Dune height and number of turtle nesting activities observed in 2017 – 2018 at Keta Ramsar site

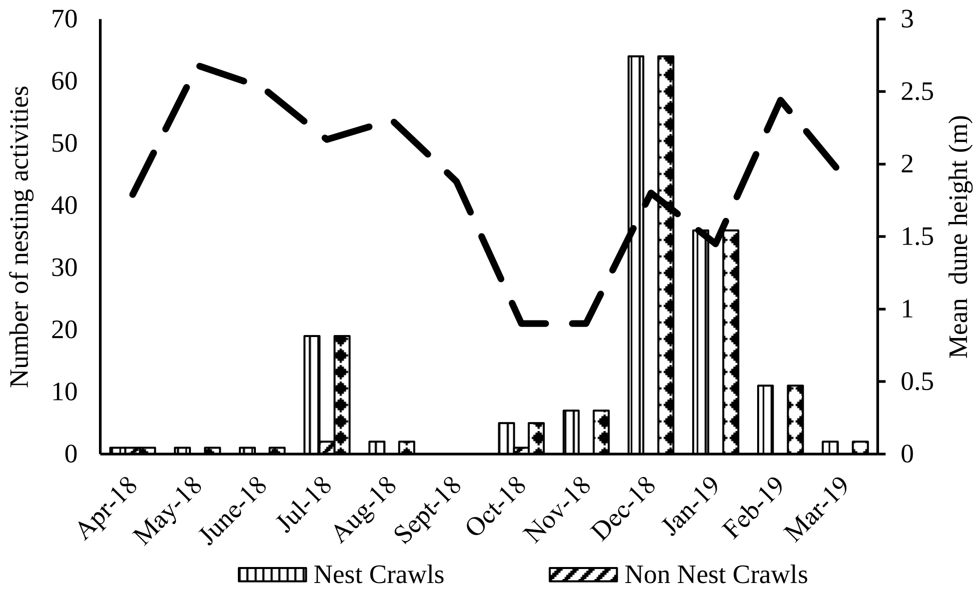

Figure 99: Dune height and number of turtle nesting activities observed in 2018 – 2019 at Keta Ramsar site

Erosion, accretion and turtle nesting activities at Keta Ramsar site

Moderate erosion was recorded between December and January, ranging between 19.57 and 26.55m during 2017 - 2018 sampling period (Figure 99). The period was characterised by the presence of live turtles. Erosion values recorded were high in September 2017 to November 2017 and January 2018 to March 2018, with values between 10.10 and 79.43m. Turtle nesting activities were low during the period except November 2017 where moderate nesting activities were observed (Figure 99). High erosion values were recorded in April 2018, May 2018, September 2019 and February 2019 during 2018 - 2019 sampling period. These periods were characterised by low to no turtle nesting activities (Figure 100). Turtle nesting activities improved within July 2018, December 2018 and January 2019, probably due to low erosion rates and a relatively conducive shoreline.

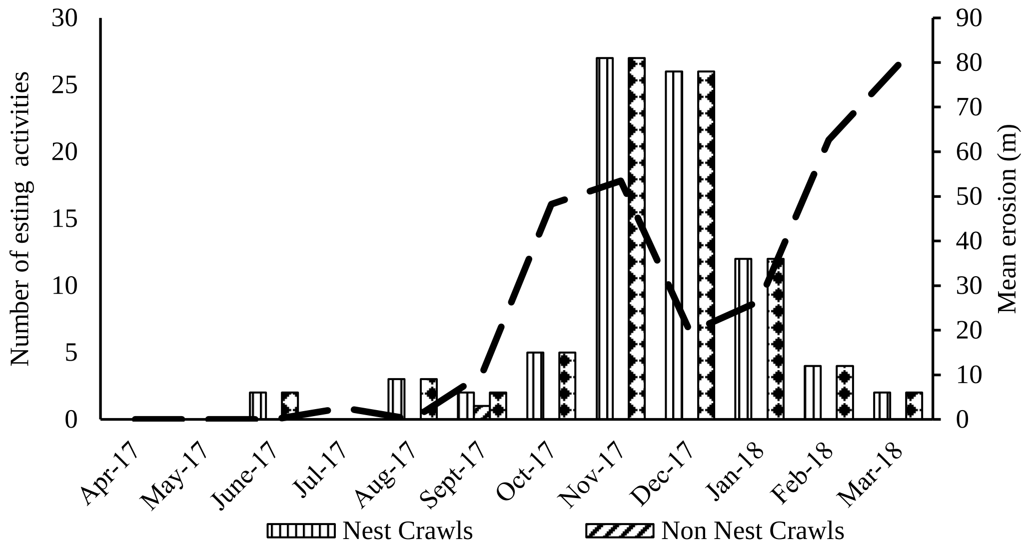

Figure 100: Erosion and occurrence of number of turtle nesting activities observed in 2017 - 2018 period at Keta Ramsar site

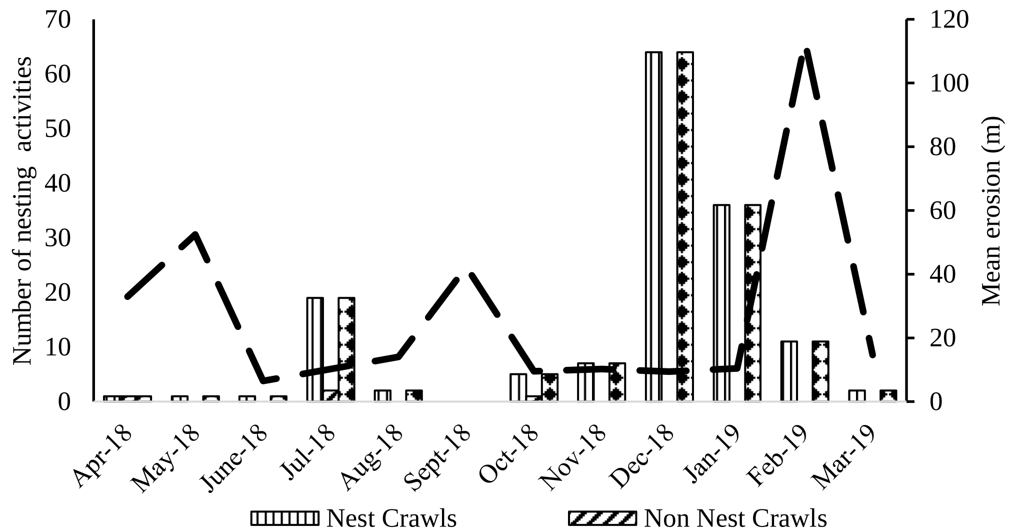

Figure 101: Erosion and occurrence of number of turtle nesting activities in 2018 - 2019 period at Keta Ramsar site

Uneven moderate beach accretion occurred during 2017 - 2018 sampling period. The lowest beach accretion occurred in November 2017; 13.58m. Live turtles were recorded within the months of November 2017, December 2017 and January 2018 (Figure 101). During the 2018 - 2019 sampling period, beach accretion was uneven. The highest monthly average accretion rate of 116.10m occurred in January 2019. Turtles that emerged from sea were observed in October 2018 and December 2018 (Figure 101).

Relative high accretion values recorded in 2017 - 2018 was characterised by a stable shoreline within the sampling area. Uneven accretion values were recorded from July 2017 to March 2018. Turtle nesting activities were unevenly distributed between August 2017 and March 2018 (Figure 101). The peak nesting activity season occurred between November 2017 and January 2018. Coincidentally, beach accretion was high within this same period.

Uneven accretion values were recorded during 2018 - 2019 sampling period. Nesting activities were evenly distributed during the period. The nesting activities were concentrated in July 2018 and between November 2018 and January 2019 (Figure 102).

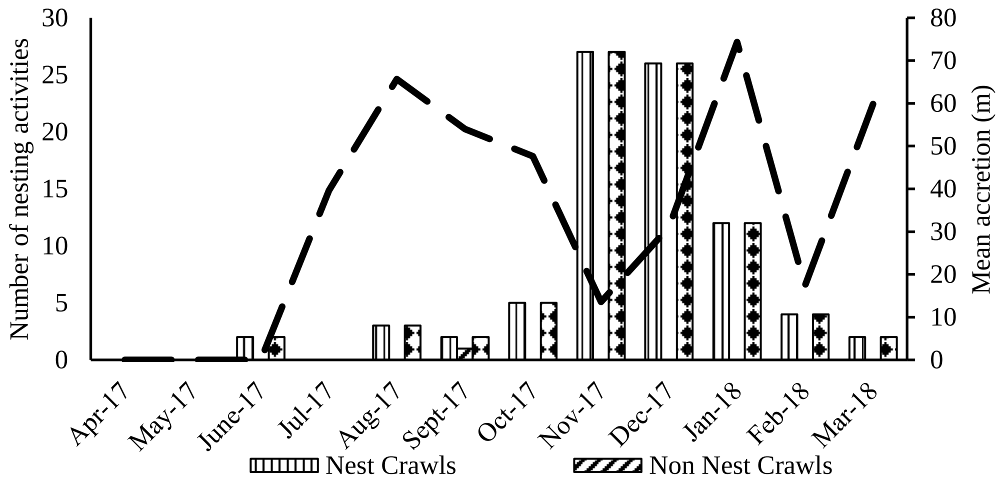

Figure 102: Accretion and number of turtle nesting activities observed in 2017 - 2018 period at Keta Ramsar site

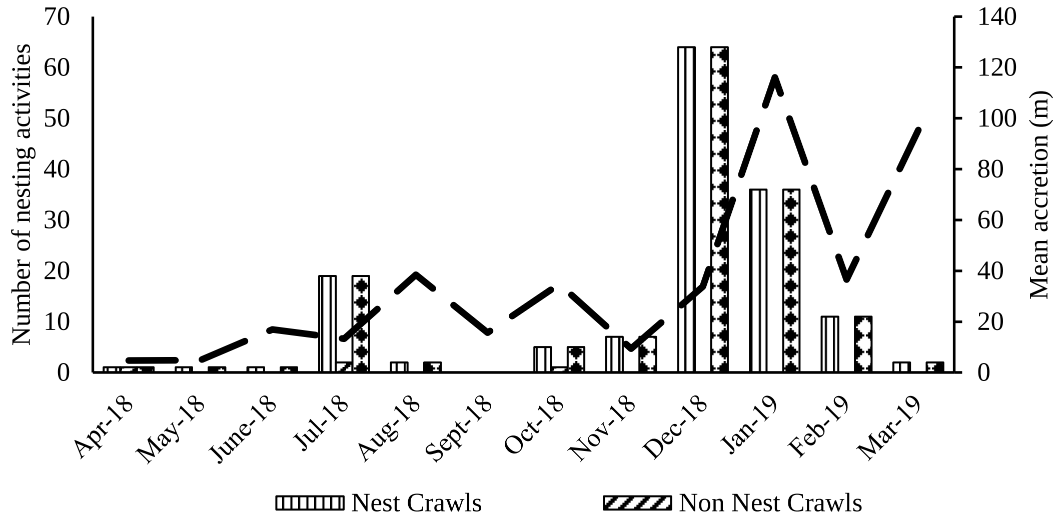

Figure 103: Accretion and number of turtle nesting activities observed in 2018 - 2019 period at Keta Ramsar site

Data on Turtle Species and Characteristics of Nest and Nesting Habitats at Songor Ramsar Site

Tables 3 - 6 indicate turtle species and varied characteristics recorded on turtle nest within the sampling sites.

Table 3: Turtle species and characteristics of nest within sampling site 1, 2017 – 2018 at Songor Ramsar site.

Site 1	**nature of beach**			**nest distance**			**substrate depth (cm)**		
species	**natural**	**nourished**	**nest depth (cm)**	**from mean tidal mark (m)**	**soil texture**	**particle size (µm)**	**sand**	**clay**	**dune height (cm)**
Lepidochelys olivacea	13		48-60	4.5-10.5	fine	0.05-0.005	80-100	-	25+
	10		48-60	10.6-36.5	fine	0.05-0.005	80-110	-	35+
	1		15-20	43	coarse	0.5-0.05	25-25	30	45+
		3	15-20	25-35	coarse	0.5-0.05	20-25	30	55+
Chelolonia mydas	1		72	16.1	fine	0.05-0.005	110	-	25+
Dermochelys coriacea	10		110-120+	3.0-10.5	fine	0.05-0.005	110+	-	45+
	9		110-120+	10.5-24.5	fine	0.05-0.005	110+	-	35+
	2		110-120+	25.5 - 35.5	fine	0.05-0.005	110+	-	15+
		1	-	39.9	coarse	0.5-0.05	30	-	45+
	8		110-120+	(-2.0) - (-8.0)	fine	0.05-0.005	110+	-	45+
	2		110-120+	(-10.0) - (-14.0)	fine	0.05-0.005	110+	-	55+
	56	**4**							

Table 4: Turtle species and characteristics of nest within sampling site 2, 2017 - 2018 at Songor Ramsar site

Site 2	**nature of beach/ no. of nests**			**nest distance**			**substrate depth (cm)**		
species	**natural**	**nourished**	**nest depth (cm)**	**from mean tidal mark (m)**	**soil texture**	**particle size (µm)**	**sand**	**clay**	**dune height (cm)**
Lepidochelys olivacea	23		45-49	3.5- 11.5	fine	0.05-0.005	80-90	-	25+
	17		50-60	12.0-34.5	fine	0.05-0.005	100-120	-	35+
	1		51	-1.3	fine	0.05-0.005	110	-	75+
Chelolonia mydas	3		65-80	5.5-23.5	fine	0.05-0.005	100	-	35+
Dermochelys coriacea	18		110-120+	2.0-12.5	fine	0.05-0.005	110+	-	35+
	6		110-120+	12.6-29.5	fine	0.05-0.005	110+	-	25+
	8		110-120+	(- 3.5) - (-7.5)	fine	0.05-0.005	110+	-	45+
	76								

Table 5: Turtle species and characteristics of nest within sampling site 1, 2018 – 2019 at Songor Ramsar site

Site 1	**nature of beach/ no. of nests**			**nest distance**			**substrate depth (cm)**		
species	**natural**	**nourished**	**nest depth (cm)**	**From mean tidal mark (m)**	**soil texture**	**particle size (µm)**	**sand**	**clay**	**dune height (cm)**
Lepidochelys	4		46-48	1.0 - 4.0	fine	0.05-0.005	90-100	-	55+
olivacea	3		47-48	11.0 -15.0	fine	0.05-0.005	80-100	-	45+
	5		48	22.0 - 31.0	fine	0.05-0.005	100	-	35+
	1		48	53	fine	0.05-0.005	90-100	-	45+
		1	35	19	coarse	0.5-0.05	55	-	55+
		1	42	6	coarse	0.5-0.05	80	-	65+
Dermochelys	16		100 - 120	2.0 - 13.0	fine	0.05-0.005	120 - 120+	-	25-30
coriacea	5		100 - 110	18.0-39.0	fine	0.05-0.005	120 - 120+	-	35 -45
	31		100 - 110	(-11) - (-12)	fine	0.05-0.005	120 - 120+	-	55 - 75
	2		100 - 110	(-13) - (-21)	fine	0.05-0.005	120 - 120+	-	85 - 120
	3		100 - 110	(-41) - (-52)	fine	0.05-0.005	120 - 120+	-	130-160
	70	**2**							

Table 6: Turtle species and characteristics of nest within sampling site 2, 2018 – 2019 at Songor Ramsar site

Site 2	**nature of beach/ no. of nests**			**nest distance**			**substrate depth (cm)**		
species	**natural**	**nourished**	**nest depth (cm)**	**from mean tidal mark (m)**	**soil texture**	**particle size (µm)**	**sand**	**clay**	**dune height (cm)**
Lepidochelys	9		45 - 52	1.0 - 12.0	fine	0.05-0.005	80 - 100	-	25 - 40
olivacea	5		48 - 52	13.0 -24.0	fine	0.05-0.005	90 - 100	-	25 - 35
	2		48	25.0 - 44.0	fine	0.05-0.005	90 - 110	-	35 - 45
	1		48	154	fine	0.05-0.005	100	-	35
	1		47	-14	fine	0.05-0.005	100	-	80
Dermochelys	46		100 - 110	2.0 - 11.0	fine	0.05-0.005	120 - 120+	-	10.0 - 15.0
coriacea	11		100 - 110	12.0 - 20.0	fine	0.05-0.005	110 - 120	-	15.0 - 25.0
	4		100 - 110	23.0 - 40.0	fine	0.05-0.005	110 - 120	-	25.0 - 35.0
	3		100 - 110	41.0 - 49.0	fine	0.05-0.005	120 - 120+	-	35.0 - 40.0
	29		100 - 110	(-2) - (-10)	fine	0.05-0.005	110 - 120	-	-60.0 - 70.0
	2		100 - 110	(-12) - (- 21)	fine	0.05-0.005	120 - 120+	-	70.0 - 80.0
	113								

The result indicated the occurrence of turtle nest on the natural and nourished beach. Out of 321 turtle nests encountered, 315 nest were located on natural sandy beach whilst 6 occurred on nourished sand (Tables 3 - 6). These included the nests of 96 *L. olivacea*, 4 *C. mydas* and 215 *D. coriacea.* Six nests were located on the nourished beach of which 5 belonged to the *L. olivacea* and 1 to the *D, coriacea.*

It was observed that a total of 132 turtle nests were recorded in 2017 - 2018 sampling period (Tables 3 and 4). Out of these 128 nests occurred on natural accreted sand constituting 96.97% of turtle nests recorded, whiles 4 nets that constitute 3.03% occurred on the nourished sand. During 2018 - 2019 period 183 nest were recorded of which 181 (98.91%) occurred on natural accreted sand whiles 1.09% occurred on nourished sand, probably due to the availability of conducive environmental conditions (Tables 3 and 4).

Natural accreted beach had fine textured sand with granulometric average size that ranges between 0.005 and 0.05 μm. Turtle nests sampled on the natural sand had an average depth range of 42.0 and 60.0cm that belonged to the *L. olivacea,* 90.0 and 120.0cm for *D. coriacea* and 65.0 and 80.0cm for the *C. mydas.* Distance of turtle nest from mean tidal mark varied among the species. The average nest distance recorded for *L. olivacea* turtle was in the range of - 41 and 154m, D. coriacea -52 and 49.0m and *C. mydas* 5.5 and 23.5m (Tables 3 – 6).

Substrate under natural accreted and nourished sand were basically clay, calcareous sand and laterite. They were located within depth that ranges between 55.0 and 120cm. Turtle nests sampled on natural sandy beach were normally observed to be located above the substrates.; *L. olivacea* ± 60cm, C. mydas) ± 40cm, *D. coriacea* ± 10cm (Tables 3 – 6).

Nourished beach had dredged sand that was coarse textured and had grain size that ranges between 0.05 and 0.5 μm. Nesting turtles normally were unable to dig to create nest on the nourished beach sand. Turtles occasionally abandoned nesting process when they could not dig. Nest that were located on the nourished beach were observed to be shallow and the nest depth ranges between 15.0 and 20.0cm. The nests were mainly created by *L. olivacea*. Substrates under the nest limited digging by turtles to attain the required nest depth. Although, laterite and coarse sand existed, turtles nest were observed to have mostly clay and calcareous sand as the substrate. The substrate depth, which was shallow, ranges between 20.0 and 80.0cm. Nest were located between 6.0 and 40m from the mean tidal mark. Turtle nests were generally observed to be located further away from mean tidal mark (MTM) when dunes heights were lower but below the mean tidal mark when the dunes were exceptionally higher (Tables 3 and 6).

Data on Turtle Species and Characteristics of Nest and Nesting Habitats at Keta Lagoon Complex Ramsar site

A total of 228 turtle nests occurred on the natural accreted sandy beach (Tables 7 – 14). Out these, 46 were *L. olivacea* nests and 182 were *D. coriacea* nests. Recession project existed along section of the beach of the sampling area and no visible nourished sand was observed.

Table 7: Turtle species and characteristics of nest within sampling site 1, 2017 – 2018 at Keta Ramsar site

Site 1	**nature of beach/ no. of nests**			**nest distance**			**substrate depth (cm)**		
species	**natural**	**nourished**	**nest depth (cm)**	**from mean tidal mark (m)**	**soil texture**	**particle size (µm)**	**sand**	**clay**	**dune height (cm)**
Lepidochelys	3		46-52	6.0-10.0	fine	0.05 - 0.005	100	-	25 - 35
olivacea	7		48-52	7.0 - 19.0	fine	0.05 - 0.005	115	-	15 - 25
Dermochelys	18		98-102	3.0-10.0	fine	0.05 - 0.005	120+	-	35-45
coriacea	2		100-115	11.0- 15.0	fine	0.05 - 0.005	120+	-	25-35
	11		100-115	16.0-24.0	fine	0.05 - 0.005	120+	-	25-35
	6		112	(-3.0) - (-10.0)	fine	0.05 - 0.005	120	-	45-75
	47								

Table 8: Turtle species and characteristics of nest within sampling site 2, 2017 – 2018, at Keta Ramsar site

Site 2	**nature of beach/ no. of nests**			**nest distance**			**substrate depth (cm)**		
species	**natural**	**nourished**	**nest depth (cm)**	**from mean tidal mark (m)**	**soil texture**	**grain size (µm)**	**sand**	**clay**	**dune height (cm)**
Dermochelys	1		110	4.2	fine	0.05-0.005	120	-	35-45
coriacea	1		110	97.2	fine	0.05-0.005	120	-	15-25
	1		118	-4.3	fine	0.05-0.005	120	-	55-75
	1		116	-6.4	coarse	0.5 - 0.05	110	-	65-80
	4								

Table 9: Turtle species and characteristics of nest within sampling site 3, 2017 – 2018, at Keta Ramsar site

Site 3 species	nature of beach/ no. of nests natural	 nourished	nest depth (cm)	nest distance from mean tidal mark (m)	soil texture	particle size (µm)	substrate depth (cm) sand	 clay	dune height (cm)
Lepidochelys	3		45-48	2.0-7.0	fine	0.05 - 0.005	85-95	-	35-45
olivacea	3		48-52	12.0-24.0	fine	0.05 - 0.005	100	-	25-35
	2		48-52	(-2.0) - (-5.0)	fine	0.05 - 0.005	95-110	-	65-80
Dermochelys	4		98-112	4.0-10.0	fine	0.05 - 0.005	120	-	10.0 - 15.0
coriacea	7		110	11.0-17.0	fine	0.05 - 0.005	120	-	10.0 - 20.0
	3		110	18.0-33.0	fine	0.05 - 0.005	120	-	15.0 - 25.0
	2		110+	(- 2.0) - (-8.0)	fine	0.05 - 0.005	120	-	55.0 - 65.0
	6		110+	(-8.5)- (-16.5)	fine	0.05 - 0.005	120	-	75.0 - 80.0
	30								

Table 10: Turtle species and characteristics of nest within sampling site 4, 2017 – 2018, Keta Ramsar site

Site 4	**nature of beach/ no. of nests**			**nest distance**			**substrate depth (cm)**		
species	**natural**	**nourished**	**nest depth (cm)**	**from mean tidal mark (m)**	**soil texture**	**particle size (µm)**	**sand**	**clay**	**dune height (cm)**
Lepidochelys olivacea	3		48-52	18.0 - 24.0	fine	0.05 - 0.005	100	-	35-45
Dermochelys coriacea	1		107	3.6	fine	0.05 - 0.005	120	-	25 - 35
	4								

Table 11: Turtle species and characteristics of nest within sampling site 1, 2018 – 2019 at Keta Ramsar site

Site 1	**nature of beach/ nest sampled**			**nest distance**			**substrate depth (cm)**		
species	**natural**	**nourished**	**nest depth (cm)**	**from mean tidal mark (m)**	**soil texture**	**particle size (µm)**	**sand**	**clay**	**dune ht (cm)**
Lepidochelys	9		48-51	1.0 - 19 .0	fine	0.05 - 0.005	75 - 100	-	20.0 - 45.0
olivacea	8		38 - 49	20.0 - 30.0	fine	0.05 - 0.005	80 - 90	-	55.0 - 75.0
Dermochelys	28		100 - 110	2.0 - 19.0	fine	0.05 - 0.005	110 - 120	-	10.0 - 40. 0
coriacea	2		100 - 110	20.0 - 39.0	fine	0.05 - 0.005	110 - 120	-	45.0 - 55.0
	14		100 - 110	(-1.0) - (- 9.0)	fine	0.05 - 0.005	110 - 120	-	45.0 - 55.0
	2		100 - 110	(-10.0) - (- 20.0)	fine	0.05 - 0.005	110 - 120	-	60.0 - 75.0
	63								

Table 12: Turtle species and characteristics of nest within sampling site 2, 2018 – 2019, at Keta Ramsar site

Site 2	nature of beach/ nest sampled			nest distance			substrate depth (cm)		
species	natural	nourished	nest depth (cm)	from mean tidal mark (m)	soil texture	particle size (µm)	sand	clay	dune ht (cm)
Lepidochelys	1		52	12	fine	0.05 - 0.005	120	-	45.0
olivacea	1		46	8.4	fine	0.05 - 0.005	90	-	10.0
Dermochelys	21		100 - 110	3.0 - 9.0	fine	0.05 - 0.005	110 - 120	-	10.0 - 15.0
coriacea	1		100 - 110	10.0 - 15.0	fine	0.05 - 0.005	110 - 120	-	20.0 - 25.0
	5		100 - 110	(-3.0) - (-9.0)	fine	0.05 - 0.005	120 - 120+	-	30.0 - 55.0
	29								

Table 13: Turtle species and characteristics of nest within sampling site 3, 2018 – 2019 at Keta Ramsar site

Site 3 species	nature of beach/ nest sampled natural	nourished	nest depth (cm)	nest distance from mean tidal mark (m)	soil texture	particle size (µm)	substrate depth (cm) sand	clay	dune ht (cm)
Lepidochelys	4		42-48	5.0 - 20.0	fine	0.05 - 0.005	80 - 100	-	10.0 - 25.-
olivacea	2		48	25.0 - 45.0	fine	0.05 - 0.005	80. - 100	-	30.0 - 45.0
	2		46-48	(-5) - (-25)	fine	0.05 - 0.005	100	-	55.0 - 75.0
Dermochelys	27		100 - 110	1.0 - 19.0	fine	0.05 - 0.005	100 - 120	-	10.0 - 20.0
coriacea	3		100 - 110	20.0 - 40.0	fine	0.05 - 0.005	100 - 120	-	25.0 - 35.0
	4		100 - 110	(- 2) - (- 10)	fine	0.05 - 0.005	120+	-	40.0 - 55.0
	1		100	(-11) - (- 29)	fine	0.05 - 0.005	120+	-	40.0 - 55.0
	1		110	(- 35) - (- 55)	fine	0.05 - 0.005	120+	-	40.0 - 55.0
	44								

Table 14: Turtle species and characteristics of nest within sampling site 4, 2018 – 2019, at Keta Ramsar site

Site 4 species	nature of beach/ nest sampled natural	nourished	nest depth (cm)	nest distance from mean tidal mark (m)	soil texture	particle size (µm)	substrate depth (cm) sand	clay	dune ht (cm)
Dermochelys	6		100 110	1.0 - 20.0	fine	0.05 - 0.005	120	-	10.0 - 15.0
coriacea	1		100	(- 1) - (-5)	fine	0.05 - 0.005	120	-	45.0 - 55.0
	7								

A total of 85 nests were recorded on natural accreted sand during the 2017 - 2018 sampling period (Tables 7 – 10). These constituted 19 (22.35%) *L. olivacea* nests and 66 (77.65%) *D. coriacea* nests. Within the 2018 - 2019 sampling period, 143 turtle nests were recorded on natural accreted sand. These constituted 27 (18.88%) *L. olivacea* nests and 116 (81.12%) *D. coriacea* nests (Tables 11 - 14).

Natural sand deposited along the beach of the sampling area was observed to be fine textured with average granulometric size between 0.005 and 0.05μm (Table 11 - 14). The depth of *L. olivacea* nests recorded on the natural sand ranges between 38.0 and 52.0cm whilst nests depth of *D. coriacea* ranges between 98.0 and 110.0cm (Table 11 - 14). The distance of turtle nests measured from the highest tidal mark (MTM) varied with nesting species. *L. olivacea* nests were located within distances that ranges between -14.0 and 154.0m from the highest tidal mark, whilst *D. coriacea* nests were located between the range of -55.0 and 110.0m. Heights of sand dunes varied along the beach with an average height that ranges between 10.0 and 80.0cm. The presence of high dunes along the beach influenced turtle nesting processes by limiting access to suitable nesting sites. Substrate under natural accreted sandy beach was observed mainly to be clay that was located within depths between 75.0 and 120.0cm. All the nests of turtle species sampled on the natural beach within the sampling area were observed to have the required nest depths (Tables 7 - 14).

CHAPTER FIVE

DISCUSSION

Occurrence and Identification of Turtle Species

The study involved comprehensive assessment of the physical changes that occur along the shoreline and the influence on nesting patterns of the turtle species that emerged from the ocean to nest.

During the 2 - year period, 4 species of turtles that utilized the sampling areas were identified. Three out of these species currently occur and nest along the coast of West Africa and Ghana as confirmed by Jacque (2001), (Patrício et al., 2019). However, E. imbricata was not recorded in the Keta Lagoon Complex Ramsar Site during the sampling period. The carcass of *E. imbricata* was recorded only in December within the Songor Ramsar site sampling site 2 during the 2017 - 2018 sampling season. In Africa the species is known to occur in Angola, Mozambique, Tanzania and Kenya. The nesting range of the species may be limited to some biogeographic regions. Marquez (1990), however, believed that *E. imbricata* nest on beaches of Cape Verde Island, Senegal, Mauritania and probably other areas. Barbosa et al. (1998), however, believed there has been confusion in the identification of the tracks between *E. imbricata* and *L. olivacea*.

Communities along the coast classified marine turtles into two for easy identification and these included 1. *D. coriacea* and 2. the others; *L. olivacea* and *C. mydas.* To the untrained eye, turtles look somewhat similar, however in fact, turtles are often misidentified. Sea turtles are represented by species that differ widely in their seasonal cycles, geographical ranges and behavior. There are also considerable differences among populations of the same species. *D.*

coriacea are identified by their unique soft leathery back, nevertheless, identifying the other species requires adequate skills. The key features used to identify turtle species are their shells and the pattern of their scutes. The different species and subspecies can be differentiated by their morphology, behaviour and geographical distribution (Appendix 45). During the study, the carapaces and scutes of live and dead turtle species were examined and identified along the shore using the FAO Species Catalogue (2004). There were no ambiguity of identification as the turtle species sighted and examined have been documented on the Ghanaian shores. It was certain however that during the study *D. coriacea* and *L. olivacea* were clearly distinguished and regarded as the most common species along the shore.

Crawling Gaits as a Complimentary Species Identification

When sea turtles come ashore to nest, each species leaves its own distinctive crawling tracks on the sand. It's not always possible to sight nesting turtles on the shore to know which species has been on the beach. When nesting females come onto the beach, they leave tracks or crawls made by their flippers. These crawls are distinctive for each species due to their unique morphology and this make species identification less cumbersome. In general, the locomotion of turtles has unique features when compared with that of other vertebrate and because of the rigid carapace, all propulsion must come from the limbs. While all terrestrial turtles and freshwater turtles (with the exception of (*Carettochelys*) utilize diagonally alternate limb movements to swim or crawl, marine turtles use both forelimbs simultaneously (Lohmann et al., 1990). Crawls or gaits of 3 turtle species *D coriacea*, *L. olivacea* and Green turtles *C. mydas* encountered on the beach were categorized as symmetrical or asymmetrical crawling gaits. Dogpaddling crawling are made by *Caretta*, *Eretmochelys*, *Lepidochelys* and hatchlings of *Chelonia*. The power stroke is an asymmetrical gait which are also used by adult *Chelonia* and *Dermochelys* during crawling. As marine turtles approach adulthood and their mass increase, they support themselves on the carpus and anterior edge of the manus rather than the palmar surface (Lohmann et al., 1990). Cheloniid hatchlings crawl by protracting and retracting diagonally opposite limbs. Calabrese (2019) described the distinction between C. *mydas* and *Carreta carreta*; Carreta *carreta* tracks will appear as staggered, comma-shaped indentations. The staggered nature is due to an alternating gait, rather than a simultaneous, parallel push of both hind flippers.

Some of the distinctive features of nesting turtle tracks observed along the shore that complimented the identification procedure included the following; C. *myda*s tracks - parallel flipper marks as from a "butterfly-stroke" crawling pattern. Ridged track center with a thin, straight, and well-defined tail-drag mark that is punctuated by tail-point marks. *D coriacea* – parallel flipper marks as from a "butterfly-stroke" crawling pattern. Ridged track center with a thin, straight, and well-defined tail-drag mark that is punctuated by tail-point marks. Extensive markings from front flippers at the margins of the track and extending the total track width to 1.3 to 1.5 cm.

Morphometric and size of Turtle Species

The size frequency of a population is an important parameter of that population's demographic structure. Analyses of growth rates can indicate habitat quality and physiological status. The size of turtles are relatively related to the length of the carapace which is mostly considered as a reliable measure of the overall size. The size has also been relatively related to turtle maturity as Witherington et al. (2006a) and Witherington et al., (2006b) assigned morphometric data to life stages of turtle species.

The mean size of turtles measured on the beach exhibited significant variation within the species and between the sampling areas. The size of the same species compared within the Songor Ramsar site showed slight form of variations. This suggested that a cohort of adult female species visited the sampling area during the nesting season. The mean curved carapace length (CCL_m) of emergent Olive ridley turtles recorded within the sampling areas does not vary from other nesting beaches as confirmed by Marquez (1990) studies in Honduras 58.5-75cm, Guyana 68.1cm, Surinam 63-75cm, Colombia 52-75cm, Mozambique 65.4cm and Sri Lanka 68-79cm.

The *Dermochelys coriacea* species was the largest species that was measured during the study period. However, habitat changes have impacted negatively on this species as it struggles to overcome dunes and other barriers on the shore to nest due to its huge size. *Dermochelys coriacea* species is not only the largest living sea turtle, but also one of the largest including extant reptiles. Across the sampling area, the size of the turtle species recorded varied. Differences in age and environmental stressors might account for the differences. Compared to other nesting beaches, the mean curved carapace length (CCL_m) does not vary as documented by Marquez (1990); mean CCLmin measurement from Trinidad nesting beach was 156.5 cm, Colombia 155.6 cm, French Guiana 158.5 cm. Straight carapace length (SCL) of one female measured in Senegal was 183 cm (Marquez, 1990). Only adult females species were measured during the period and there was limitation in comparing morphological size of sexes. However, the size class of the species measured did not vary among the species and between the sampling areas.

Occurrence of Turtle Species and Nesting Activities

The study revealed the trend of turtle species and nesting activities along the shores of the study area. The results indicated an uneven occurrence, distribution and abundance of turtle species and nesting activities along the shore as reported by Carr & Carr (1991), Fretey (2001) and Barbosa et al. (2018) along the coast of West Africa and Ghana. Ghana coast covers 550 km of beach (Dankwah et al., 1999) of which 14.54% constituted the study area. Earlier studies indicated that 6 species of nesting turtles occurred within the Atlantic coast of Africa and these included *Caretta caretta, Lepidochelys kempii, Lepidochelys olivacea, Chelonia mydas, Erectmochelys imbricata* and *Dermochelys coriacea* (UNEP/CMS, 2000). A study by Carr and Campbell, 1995, suggested that approximately 75% of Ghana's coastline was suitable for nesting turtles. The same study, however, contested the suitability of some coastal habitats as nesting sites for turtles. The study at the period revealed that most of the beach from Newtown eastward to the village of Bakanta was narrow, Legu to Mankwandze beach was rocky and mostly washed out and the shore along Cape Coast to Moree was unsuitable. The distribution and abundance of the species recorded along the coast of the study area has reduced and this may have been influenced by geographical migratory pathway, the aggregation within the feeding and breeding grounds, changes in the nesting habitat and a display of fidelity promulgated by some turtle researchers.

Bowen et al (1998) indicated that *L. olivacea* has a circumtropical distribution and is probably the most abundant sea turtle. The species are highly gregarious and the presence of large flotillas in the open sea are well documented by Fretey (2001). *L. olivacea* occurred along the shoreline of the study area between March and August. It was the most abundant and widely distributed among the species encountered with species activities of 57.92% in the Songor Ramsar site and 30.06% in the Keta Lagoon Complex Ramsar site. However, according to Fretey, (2001) the species is declining worldwide and therefore a priority species for conservation in West Africa. It was observed that the density of nesting activities declined towards the eastward sections of the study area. The species inhabits mainly the Pacific Ocean, with some populations of a certain importance in the Western Atlantic of which Ghana forms part (Fretey, 2001). The nesting season for the Olive ridley species normally peaks between August – September. Carr & Carr (1991) suggested that, in coastal waters turtle density peaks during the breeding season, with lower densities during April– September. The uneven recorded nest density along the shores of the study areas over the 2-year study period may represent a natural abundance cycle or a change in nesting conditions or site use, rather than necessarily a decrease in the population Cruz et al. (2011).

D. coriacea reasonably occurred along the shores of the sampling areas and West Africa similar to that reported by Hughes et al., (1973), Carr & Carr (1991) and Mint Hama et al., (2013) that the species primarily occur in warmer regions. It was the most abundant species that was recorded between October and March within specified sampling sites with an increased in annual nesting activities. The species was well distributed within the study areas but was abundant towards the western sections of Songor Ramsar site. It was however, the most abundant species with most occurring activities, 69.77% within the Keta Lagoon Ramsar Complex sampling area. The distribution and abundance of the species within the Keta Lagoon Ramsar Complex compared to other species during the 2-year monitoring period is not very clear. It may be attributed to the ecosystem dynamics and to authenticate this factors further studies may be required on the species and the habitat.

The West Africa region is of global importance for the species. The region host one of the largest populations (Patricio *et al.*, 2019). During the study period the species occurred between the months of August and March. Their distribution and abundance during the sampling period was very marginal and uneven. The nest density was concentrated along the eastern section of Songor Ramsar site and was considered very low as compared to the other species. Incidentally, only one carcass was recorded along the shore of Keta Lagoon Complex Ramsar sites, indicative of the probable wider distribution of the species mostly along the shore of Songor Ramsar site.

The carcass of the *E. imbricata* was recorded only once within the Songor Ramsar sampling area. Though this could not provide adequate data on the abundance and distribution of the species, it confirms Manger (1985) study that indicated that *E. imbricata* have been reported in Ghana. The report however, failed to stipulate the specific nesting locations. Gawler and Agardy (1994), also reiterate that the species is endangered, but nesting activities have been encountered on the Ghanaian beach. *E. imbricata* are less abundant on the Western Atlantic coast. This may have accounted for the rarity of the occurrence of the species within the study areas. The species may be very common in the

East African coast as far as Madagascar where coralline coast exist and are well protected. This may support Carr and Campbell (1995), who reported that hawksbill turtles do not appear to nest in Ghana. They believed that, perhaps *E. imbricata* was locally extinct or they may have never been abundant in Ghana. Inadequate historical data on the species makes it difficult to determine why no recent evidence of nesting *E. imbricata* has been found. Additional beach surveys and interviews with local residents could provide more information regarding the status of the species in Ghana.

Seasonal Patterns of Turtle Nesting Activities

The seasonal pattern of nesting activities observed within the sampling areas seems to agree with the studies by Fretey (2001), Carr and Campbell (1995), who documented the existence and nesting patterns of turtle species along the coastline of Ghana. Accra – Anyamam beach was identified as one of the nesting sites, whiles nesting period was stated to occur from July – December. Though, November – December was reported as the peak season, no specific turtle species was mentioned. The period stated covers a range of turtles that nest along the coast of Ghana.

It is not clear whether the absence of nesting activities of some species identified in early research represents a decline in the population or a change in the nesting pattern. No *C. mydas* nesting activities was recorded within the Keta Lagoon Complex Ramsar sampling area. Only 1 indeterminate dead *C. mydas* was recorded. There was also a dip in species total crawls and nest recorded in 2017 - 2018 and 2018 - 2019 along the Songor Ramsar sampling area. Fretey (2001), however, suggested that *C. mydas* are less abundant in the Eastern

Atlantic coast which include Africa. This may probably be responsible for the marginal number of recorded nesting activities of *C. mydas* during the study period. Cansdale (1955), reported *Chelonia mydas* as the most common species along the coast Gold Coast, but Brongersma (1995) found only the hatchlings of the species on the shore of Tema and suggested that the species definitely nest on the coast of Ghana. Carr and Campbell (1995), believed that *C. mydas* are not clearly distinguished from *L. olivacea*. Probably this might be the confusion in the identification of the species during their early studies. The presence of the juvenile and the adult *C. mydas* in near shore waters suggests that there is important developmental habitat for *C. mydas* in Ghanaian waters (Carr et al., 1995). Carr et al. (1995) believed that only few *C. mydas* nest during the same season as the *L. olivacea* and *D. coriacea* from October – January. The possible explanation for this may be that *C. mydas* nest during different season and possibly at different locations. It also suggests that there has been a substantial nesting population of *C. mydas* or the nesting population has been extirpated (Thomson et al., 2015). *C. mydas* turtle population seems not to have recovered along the study area (Carr and Campbell, 1995). Studies revealed that there were 12 recoveries, along the coast of Ghana and 4 were recorded (Carr and Campbell, 1995), whiles Carr et al. (1995) recorded 3 species in Gabon, Cameroon 1 and in the island of Corisco in the southern of mainland Equatorial – Guinea 4. There is the need for more studies on the species, since the data acquired on the population within the study areas was staggering and did not appreciate to any acceptable level during the study period.

Some colonies of *L. olivacea* turtle species exist in the eastern Atlantic and nesting points have been established along some West African coast

(Fretey, 2001) and (Mint Hama *et al.*, 2013). This confirms the dominance of *L. olivacea* nesting activities along the study areas in terms of distribution, occurrence and abundance during the study period. Nesting activities of *L. olivacea* were well distributed along the study areas but decreasing activities were observed towards west of Songor Ramsar site and east of Keta lagoon Complex Ramsar site. Carr and Campbell, 1995, suggested that *L. olivacea* appear to be the most abundant marine turtle present in Ghana. A study they undertook in 1994 revealed that majority of the marine turtle nests (86.3%) observed in the core nesting area were identified as nests (Carr et al., 1995). The study further revealed that both adult and juvenile size ridleys occur in coastal waters along the entire coastline suggesting that, there is developmental and foraging habitat offshore. Three hundred and sixteen (316) nest or nest attempts were from *L. olivacea* (Carr et al., 1995). This confirms the dominance of the *L. olivacea* species activities along the study area. The *L. olivacea* which were unevenly distributed across the study area occurred throughout the sampling period. This suggest that nesting and species activities may be observed throughout the year.

Only 1 dead *E. imbricate* was encountered along the Songor Ramsar sampling area. This probably presumes that the species do no longer nest along the study area or locally they were extinct. Brongersma (1982) reported of identifying the skull of hawksbill and nesting activities of hawksbill on Ghanaian beach. The species may not be well distributed and abundant as other species. Its activities and identification may also be confused with other species. Further studies dedicated to the species on the Ghanaian beach could provide scientific basis for distribution and the determination of the population status.

Marquez (1990), indicated that *D. coriacea* are not abundant in the Atlantic Ocean. The species is known to migrate over long distances (Marquez, 1990). Within the Atlantic Ocean the distribution of the species is wide but nesting activities occurred on few beaches which spans between Mauritania, Angola, Gabon, Guinea – Bissau (Catry et al., 2009) and some West African countries (Fretey, 2001). This agrees with the pattern of data obtained during the sampling period for the species. Though the species occurred between October and March it displayed wide distribution and abundant nesting activity between the sampling areas. *D. coriacea* breed circumglobally within latitudes of approximately 40^{o}N and 35^{o}N but range widely to forage in temperate and boreal waters outside the nesting season (Eckert,1999). The total number of *D. coriacea* nesting world – wide in 1995 was estimated at 34,529 females (Spotila et al., 1996). About 80% of these species were reported from sites in the Atlantic. 45.3% of activities of the species were recorded within the sampling areas, an indication of improved nesting trend along the nesting range.

The relative importance of nesting behavior was shown by the three nesting species recorded during the sampling periods. The species recorded gave positive annual nesting abundance trend but with different values. The values for *D. coriacea* showed positive value during the 2017 - 2018 and 2018 - 2019 sampling period and for all the sampling areas. *L. olivacea* showed a positive nesting trend in the Keta Lagoon Complex Ramsar sampling area. However, the species nesting values recorded during the sampling period provided a negative trend for the Songor Ramsar sampling area. The relative decrease in nest abundance at Songor Ramsar sampling area over the 2-year monitoring period may possibly be as a result of natural nesting cycle, a change in nesting conditions or use of the site and may not necessarily mean a decrease in the species numbers. A change in nesting habitat may result in a decrease in nest abundance, distribution and occurrence of nesting activities. Anthropogenic and climatic causes are major factors resulting in the alteration of turtle nesting habitat. However, turtles utilized well nourished, moderately gentle slopped and darker beaches from the result of the studies.

Threats to Nesting and Stranding Turtles

Natural and accidental deaths

A variety of human actions have impacted sea turtles' habitats and lives. Besides the direct hunting of sea turtles and their eggs, there are also indirect impacts from fishing, pollution, beach development, and climate change. Incidental capture of marine turtles in fishing are causing concern as important sources of further declines in already strongly reduced populations. Turtles captured accidentally in fishing nets may not be released in some communities along the coast of Ghana. Nets are not intentionally set to catch turtles, but adult or juvenile turtles that are captured are consumed regardless of size or species (Carr et al., 1995). Fretey (2001), observed that accidental death of marine turtles captured in shrimp trawls is a major threat to turtles in many areas. Dead turtles occurred on the beach, but it was difficult to determine the cause of turtle deaths within the study area, since these deaths mostly occur in the wider sea and the carcasses were washed ashore. The only subjective causes that were established upon physical examination of some of the dead turtles were bloated throat and fractured skull. The bloated throat may probably be attributed to drowning whiles the fractured skull may be due to physical abuse or collusion with fishing trawlers, boats or canoes. Turtle deaths recorded within the sampling area were high during the peak nesting seasons of *L. olivacea*. The basic presumption is that most of the dead turtles were females. The study of the carcasses along the shore during the period revealed that 60.55% were female turtles (n=330). This has serious consequence on the future of nesting populations within the study area. Carr and Campbell (1995), concluded that out of 140 turtle carcasses (including shells and partial carcasses encountered during field surveys, 56.4% (n = 79) were adult females taken from the nesting beaches. The causes of turtle deaths need to be investigated beyond the study area as most of the dead turtles were believed to have been drifted from the western section of the study area (ie from Tema and Accra). The number of dead turtles consistently decreased from Songor Ramsar sampling area towards the east of the study area, Keta Lagoon Complex Ramsar site during the entire sampling periods. Nets with bigger mesh sizes were believed to normally trap and kill Olive ridleys. This nest was set targeting larger fishes in the ocean (normally referred to as shark nets). It can also be attributed to the presence of pair trawling vessels that coincidentally were numerous on the sea in the night during the peak nesting periods.

Poaching of stranding and nesting turtles

Illegal taking of stranded or nesting turtles on the beach is an old practice that is very common among most coastal communities in Ghana. There was adequate evidence that indiscriminate harvest of nesting females and their eggs occur along the entire beach and appears to be a serious threat to the survival of nesting populations. The practice was pervasive in the study area especially within Keta Lagoon Complex Ramsar sampling area. This is consistent with the study made by Groombridge and Luxmoore, (1989), that both turtle meat and eggs are eaten by the inhabitants of Ghana. Eggs and adults turtles are regularly taken and what is not for subsistence is taken to the markets for sale. Carr and Campbell (1995), believed that nesting females and their eggs are harvested and either consumed locally or sold.

Predation of eggs in turtle nests

Sea turtles are oviparous and construct their nests along segments of the shore where they deemed appropriate. After turtles have successfully undergone the nesting process, the nests are exposed to profound environmental changes during incubation. During incubation, a wide range of predators may prey on sea turtle nests with eggs and that have a significant effect on hatchling recruitment and thus long-term population persistence (Stancyk, 1995). The biophysical changes that occur along the nesting habitat also predisposes the nests to chemical influences, flooding and desiccating. Carr and Campbell (1995), acknowledged that the eggs of *l. olivacea* were harvested along the coast of Ghana and consumed locally. The survey also suggested that majority of the turtle nests were destroyed primarily by dogs and pigs. Predation of eggs in turtle nests decreases the recruitment of hatchlings and has become an important challenge for the conservation of egg-laying reptiles (Leighton et al., 2010). Hence, understanding the activity of predators adjacent to endangered reptilian species breeding aggregations is important for designing conservation strategies.

Predation of eggs in turtle nests by both native and feral animals has become a significant threat to marine turtles around the world (Garmestani and Percival, 2005; Limpus, 2008; Jacques et al., 2022). During the survey it was observed that 3 categories of predators occurred within the sampling areas. These included feral dogs and wild animals such as crows, hawks, kites and ghost crabs. Others included humans and domestic animals such as chicken, dogs and pigs.

Unsuccessful Nest Predatory Attempt (USPA)

It was a failed attempt by a predator to locate and preyed on a particular turtle species nests with eggs. In order to sustain turtle populations, the IUCN recommends that at least 70% of total eggs laid should remain protected (no. of egg loss > 30%) (Eckert et al., 1999). The data from this study falls short of the threshold, with 32.6% of turtle nests having been successfully depredated to some level, 30.7% (n = 178) of nests however, were completely depredated. The study area was not far from the required IUCN threshold, but to achieve this, strategic long-term nest management measures beyond the study area is required to protect nesting turtles, nests and eggs of turtles during the nesting season.

Shoreline Changes and Turtle Nesting Activities

Occurrence of landforms

Factors influencing shoreline changes were monitored and it was observed that erosion, accretion and sand dunes all showed critical levels across the nesting ecosystem. The shoreline exhibited significant spatial and temporal variability. Erosion, accretion and sand dunes were the most variable parameter reflecting different landmarks at different parts of the shoreline. The study confirmed that erosion has occurred continuously and at a comparable rate and pattern. The coast of West Africa is relatively free of indentations and its dominated by sandy beaches which are constantly changing due to erosion and deposit of sand (Fretey, 2001). This has also been confirmed by Desmond et al, (2013). This has been exacerbated by rapid climatic changes, rising sea levels, shoreline orientation and anthropogenic activities (Mazaris et al., 2015). These changes obviously affected the morphology of the shoreline and eventually turtles that emerged from the ocean to nest on the sandy beach. The rate of erosion at the site was about two orders of magnitude greater than the rate of sea-level rise as confirmed by Zhang et al. (2004). Thus, sea-level rise may cause a significant loss of sea turtle nesting habitat as suggested by Fish et al. (2008). Three major landmarks that were normally left on the beach after this change included erosion of the beach, accretion along the beach and sand dunes that determined access to the beach by turtles that emerge from the sea (Morton & Sallenger, 2003). Depending on the nature of the beach and agents responsible for the beach erosion, physical landmarks that were left on the shoreline had varied morphology. The shoreline within the sampling areas had undergone tremendous erosion due to the loose sand at the beach. The construction of the Akosombo dam rendered the area very erodible (Ly, 1980) and also had adverse impact on human activities. Erosion caused by excessive waves and storms was very evident by the landmarks they left and these mostly include high sand dunes, steep dune slopes, irregular and unstable shoreline. Shoreline erosion was prominent in areas without sea recession projects. This probably was caused by storms that intermittently occurred between October 2017 and March 2018, interspersed with high mean beach erosion (Appendix 7). Monthly mean accretion values recorded were high in sampling in November 2017 (Appendix 5) and February 2019 (appendix 14). These and other marginal monthly values might be responsible for the high accretion values across the sampling areas. A trend that immerged suggested that high monthly accretion was subsequently preceded by erosion and vice versa. Generally, the shoreline across the sampling area was 20 – 30% marginally stable during the sampling periods. The sea recession project, occasionally, does not reduce the rate of erosion as expected within some sampling sites. Though sea recession projects existed within sampling site 1, the average monthly beach accretion recorded was very marginal and not to any appreciable level to stabilize the shoreline. This might primarily be as a result of high erosion that occurred along the shoreline of some selected sampling points within Songor Ramsar site (Appendix 4), which had fragile and unstable sandy ecosystem.

A study of the Caribbean island of Bonaire by Fish et al. (2005) found that habitat vulnerability to rising sea levels is determined by the physical characteristics of a given site; in general, narrow and low- elevation beaches are at a greater risk of habitat loss. These results are concordant with the observed vulnerability of coastal barrier islands which comprise small islands and peninsulas with offshore deposits separate from the coastline to sea level rise and increases in the frequency and intensity of oceanic storms (Feagin et al., 2010). Comparatively, the shoreline within the Songor Ramsar sampling area was stable during the sampling period. The area recorded less mean erosion values and experience moderately less monthly erosion rates. During 2018 -

2019 sampling period there was a deviation from the 2017 - 2018 trend within the sampling area. An increase in erosion level by 16.39% occurred within the sampling area. Keta Lagoon Complex Ramsar sampling area depicted an increase of 10.16% in erosion rates. However, the Keta Lagoon Complex Ramsar sampling area demonstrated an uncertainty in erosion trend within selected sampling sites. Across the sampling areas moderate to high dunes generally were associated with period of high erosion. The dunes formed were common along the shoreline normally after storms and excessive waves. It was however, observed that the shoreline recovers after periods of continual sand accretion.

Erosion and Turtle Nesting Activities

Erosion is a major threat to emergent turtles along most nesting coast. It determines the topography which affects the suitability of the turtle nesting habitats (Ekert, 1987; Mazaris et al., 2009), as it creates barriers that prevent turtles from assessing appropriate nesting habitats. Within Songor Ramsar site, spatial distribution of nesting activities was related to physical characteristics of the coast. Turtle numbers and nesting activities were influenced by erosion that causes shoreline changes and this process altered the condition of available nesting habitat. Turtles that emerged from sea were encountered during moderate erosion periods between December 2017 and February 2018 (Appendix 4). This period also coincided with the peak-nesting season of the Leatherback turtles. Seasonal nesting activities were observed to start from March to October for *L. olivacea*, peaking between August and October. *D. coriacea* and *C. mydas* were sighted between September and early February, peaking between November to early January. During 2018 - 2019, within sampling site 2 of Songor, the average erosion recorded increased by 34.12% and there was a corresponding increase in *D. coriacea* nesting activities by 34.22%. The beach within the sampling site might have been unstable due to erosion but *D. coriacea* probably were able to locate suitable nesting sites without any barrier or threats during the period. Nest crawls and spots recorded were also observed to be high between November 2017 and January 2018 when erosion values recorded were low. Nest crawls and spots recorded increased by 28.45% during 2018 - 2019 sampling period. This may probably be attributed to 10.16% reduction in shoreline erosion during the 2018 - 2019 sampling period. The high erosion activities recorded during 2017 - 2018 sampling period might be responsible for the occurrence of low turtle nesting activities within the sampling area. The areas of nesting concentrations were characterized by the absence of groynes and the presence of relatively wide beaches with occasional strong wave actions. Turtles that emerged from sea and nesting activities showed an inverse relation with mean erosion recorded for the sampling periods. The 7.2% increase in turtle nesting activities recorded during 2017 - 2018 and 2018 - 2019 suggested a successful nesting effort by turtles even during high erosion periods. Data collected also depicted peak turtle nesting activities that coincided with high erosion periods. If the nest is laid near the waterline, erosion could result in flooding of the egg chamber (due to water reaching higher sections of the beach) or complete loss of a nest due to a high tide or storm event (Wood and Bjorndal, 2000; Bolten et al., 1999). High erosion values recorded in Keta Lagoon Complex sampling sites 1 and 3 were interestingly associated with high nesting activities during the sampling periods;

93.37% during 2017 - 2018 and 75.83% during 2018 - 2019. Though, erosion along the shore were high other favorable nesting conditions might have been responsible for the high nesting activities. These may include dark beach environment, limited human activities, availability of natural sand, less perceived threats and limited barriers that inhibited nesting activities. Non - nesting turtle crawls recorded along the period increased by 60%, which generally indicated the presence of some unfavorable nesting conditions along the entire sampling area. Forty - seven turtle nest crawls and nest spots were recorded in 2017 - 2018 when highest mean erosion was 23.92m in December 2017. There was a reduction in non-nesting crawls by 25% in 2018 - 2019, although average erosion recorded were higher as compared to 2017 - 2018. This indicated that probably nesting turtles located suitable nesting sites or did not encounter barriers or any eminent threats along the shore. Marcovaldi et al., (1996) on a study of nesting turtles in Praia do Forte, Bahia, Brazil, concluded that, turtles that nest at sites where there is an unhindered approach to the beach are relatively independent of the state of the tide for nesting and avoid the risks of being injured on reefs and rocks. Indeed, during low tides reefs may constitute a physical barrier to turtles that emerge from sea. Exposed beaches are subjected to strong wave action, which may result in the creation of wide supralittoral beaches, a common characteristic of marine turtle nesting sites. In contrast, narrow beaches where high tides cover most of the supralittoral, are unlikely to harbor successful nests. Erosion trends probably influenced the use of the sampling areas by turtle species. Erosion also created high dunes and scarps, which limited access to suitable nesting sites by turtles (Wood and Bjorndal, 2000; Maison et al., 2010). Nesting activities of *D. coriacea* occurred below mean tidal marks with an uncertain prediction of the success of the nests. Nest of turtles were sometimes inundated by saline water at high erosion periods affecting incubation process of the eggs. Pike et al., (2015), found that all stages of nest were equally vulnerable to levels of inundation. While storms and storm surge can result in the inundation of nests, future sea level rise could further threaten sea turtle nesting habitat. Occasionally, turtle nest were exposed to the wider environment by erosion and the eggs in the nest were rendered vulnerable to nest predators. It resulted in eggs being laid below the high tide line. Nests located below the tidal line were more likely to become inundated. by tidal action; eggs were more prone to being washed out (Patino-Martinez et al., 2014). Egg mortality may be higher due to the decreasing sand temperature (Houghton et al., 2007). Therefore, environment in which eggs are emplaced influences their development (Pfaller et al., 2009).

Sand Dunes and Turtle Nesting Activities

Sand dunes were one of the most visible and critical landmarks observed along the shoreline. Low mean dune heights were the result of improved accretion and reduced erosion as reflected in mean monthly values (Appendixes 9 and 15). It was possible that impacts of tidal waves, storms and erosion activities along the shore were minimal. During the period turtles were encountered within the months of September 2017 and December 2018 when mean dunes heights were low. These were moderate mean dune heights that turtle species could circumvent and select suitable nesting locations along the beach. Turtle nesting activities, nest crawls and nests spots successively increased between June 2017 and September 2017, between November 2017 and March 2018. This period coincidentally, marked the peak nesting seasons of *L. olivacea* and *D. coriacea*. The turtles might have overcome the dunes as barriers or located suitable nesting locations along the same shoreline. The high dunes recorded during 2018 - 2019 influenced turtle nesting activities. Nesting activities occurred between September 2018 and February 2019 during the sampling period. There was 7.2% (n=16) increase in nesting activities in 2018 - 2019, though high dune heights were recorded. The period coincided with the peak nesting season of *D. coriacea* and *C. mydas.* The concentration of nesting activities within the period indicated a maximum turtle nesting effort and probably the availability of stable and suitable beach. Between April 2018 and August 2018, which was presumed to be the peak nesting season of *L. olivacea*, there was a dip in nesting activities. High mean dune heights from April 2018 – August 2018, might have prevented the successful use of the beach and location of safe nesting sites by nesting turtles. Within Anloga-Keta sampling area, emergent turtles were encountered when moderately low sand dunes, were recorded between September 2017 and January 2018 and between October 2018 and January 2019. Turtle nesting activities equally peaked within the same sampling periods. The low sand dune heights that coincided with the peak turtle nesting season might be responsible for the high nesting activities. Nesting activities increased by 28.45% (n = 66) during 2018 - 2019 sampling period, though dunes height along the beach were high. There was an isolated peak nesting activity in July 2018, this probably were *L. olivacea* that might contribute to the high nesting activities. There were however, lower recorded number of non-nest crawls during the sampling periods, probably due to the presence of high dunes along portions of the beach. The effect in terms of dunes formed along the beach of the sampling areas were relative. The relativity was reflected in the height of dunes and successful use of the beach by turtles that emerged from sea and the number of nesting activities. The shoreline along the Songor Ramsar sampling area had relatively low sand dunes and a stable beach resulting in 68.85% increase in turtle nesting activities. The Keta Lagoon Complex Ramsar sampling area, probably, had unstable beach and other barriers that might have limited the use of the site by turtles that emerged from sea. The beach was mostly used by the *D. coriacea* turtles. Probably, these turtles were able to circumvent the high sand dunes, successfully utilized the unstable beach and located suitable nesting sites. *D. coriacea* species activities constituted 78.21% of total turtle nesting activities recorded along the Keta Lagoon Complex Ramsar sampling area.

Accretion and Nesting Activities

Sea turtles spend most of their lives in the marine environment but they rely on the sandy beaches during reproduction. Shoreline changes affect functionality of sandy beaches as turtle nesting sites and coastal erosion is among the primary causes of shoreline changes. Loss or narrowing of sandy beaches, also called “coastal squeeze” could adversely affect sea turtle reproduction. Given that reduction of sandy beaches is predicted to further intensify in the coming decades (Brown and McLachlan, 2002), implementing beach management activities to protect biodiversity and maintain ecological processes is important (Ariza et al., 2008; James, 2000). Erosion and accretion which shapes shoreline fronts are normally preceded by waves. The associated change may be several hundred meters in beach width, but more typically is about 10 - 20m over a distance of about 1 – 2 km and may be masked locally by cusps and other small-scale beach features. Turtles have different beach space requirement for nesting. The extent of nesting habitat along the shoreline is achieved mostly through beach accretion. The extent of sand deposit on the beach through accretion could influence the conditions of the nest environment during incubation, such as temperature, extent and number of times the nest is inundated, as well as the overall success of the nest. If there is sand accretion on top of a nest, it may also decrease hatching success as hatchlings must use more energy to leave the nest chamber and reach the surface of the sand. However, some studies have reported that deeper nest remain cooler, which may allow for a higher hatching success of nests that would otherwise be incubating at the edge of the thermal tolerance zone (Booth and Astill, 2001). Within Songor there was a 32.08% reduction in beach accretion in 2018 - 2019. This was reflected in the reduction of the number of nesting activities of *L. olivacea* by 45.6%. Probably, the section of the beach where the turtles emerged from sea to nest was not conducive and safe. However, there was an increase of 25.25% nesting activities of *D. coriacea* within the same sampling area. There was a reduction in non-nesting crawls within the sampling areas. Generally, net mean monthly accretion values were moderately low to high between the months of August 2018 to March 2019. This condition not only coincided with the nesting season of the turtle species but was mostly conducive and safe. The moderate shoreline accretion recorded during 2018 - 2019 sampling period within Ada sampling site 2, a site without sea recession works, probably was due to natural sand accretion process and reduced erosion activities within the sampling site. Two peaks of shoreline accretion occurred within sampling site in May 2018 and August 2018 to February 2019. The high monthly accretion value along the shoreline of Totope, the initial sampling point of site 2 might be due to the strategic location of the last groyne of the sea recession project that seemed to trap sand along the shoreline. There was a successive increase in turtle nesting activities during 2018 - 2019 along the shoreline of the sampling area. According to a study by Leonel et al., 2013, the probability for successful nesting of the *C. mydas* in the Raudal area is directly related to the formation of its beaches. The observations in the study show that the beach chosen by the female must have extensions of not more than 20m in the distance from the sea to the supralittoral zone. Within the Keta Lagoon Complex Ramsar sampling area moderate low to high accretion values occurred. There was a corresponding increase in nesting activities of two turtle species, the *D. coriacea* and *L. olivacea*. *D. coriacea* nesting activities peaked within two samplings. Generally, in 2018 - 2019 there was consistent moderate beach accretion between July 2018 and March 2019 and this might be due to either less storm or increased deposition of natural sand during the period. *D. coriacea* nesting activities peaked from November 2018 to December 2018. The stabilized shoreline, reduced sand dune heights and dune slopes from accretional activities might be responsible for this trend. The period also coincided with the peak nesting season of the *D. coriacea*. The overall nesting season for all species extended from August 2018 to April 2019, but peak nesting seasons vary (Maria et al., 1996). The turtles probably were able to locate suitable nesting sites within the extended beach front during the nesting season.

There was a reduction in accretion of 30.18% and 38.45% within the sampling sites in 2018 - 2019. There was however, an increase in accretion of

57.70% in 2018 - 2019 within sampling site 3. Nesting activities of *D. coriacea* and *L. olivacea* peaked across the sampling site. Two accretional peak seasons were displayed during the period, June 2018 to October 2018 and December 2018 to March 2019. Turtle nesting activities were concentrated within sampling site 1 and site 3, the sites that indicated moderate shoreline accretion. Accretion alter beach morphology and this influences turtle nesting activities as many species prefer to emerge on steeper, instead of shallower beaches. Some nesting species also nest above the vegetation line in an attempt to avoid tidal waves or storms. The shoreline experienced accretion of natural sand, lowering of sand dune heights and slopes. The turtles probably were able to locate suitable nesting sites during this period. Nesting peaks were staggered between July 2018 and December 2018 to February 2019. The peak periods recorded in July 2018 was the peak nesting season of the *L. olivacea* whiles December 2018 to February 2019 was the peak season of *D. coriacea.*

Sea Recession Project and Turtle Nesting Activities

Beach nourishment is one management option to restore eroding sandy beaches. Beach nourishment has the potential to increase available sea turtle nesting habitat, however, negative impacts from nourishment have also been documented (Crain et al., 1995). The overall aim of the beach restoration was to reduce beach erosion, protect life and properties. Eventually, the nourished beach was utilized by some turtle species as nesting sites. Though marginal, the groynes played a significant role in stabilizing the shoreline during the period. The fragile ecosystem of the estuary rendered the shoreline vulnerable to sea waves and storm. High monthly erosion might be responsible for the marginal accretion values recorded. The construction of groynes with boulders trapped loose sand which are deflected towards the east and later entrapped between adjoining groynes. The accreted sand could be removed within short periods of formation by waves or storms. The boulders are exposed from this action and the arrangement is occasionally distorted rendering the beach unsafe for both human and turtles that emerge from sea to nest. The nourished sand used to reinforce groynes and stabilize the beach was compact and difficult for turtles to dig and create nest. Two turtle species mostly utilize the nourished beach, *D. coriacea* and *L. olivacea*. There was a reduction in seasonal nesting activities by 45.6% in 2018 - 2019 of *L. olivacea* and 25.25% increase in seasonal nesting activities of *D. coriacea*. Dunes formed were moderately low improving access to nesting sites on the shoreline by *L. olivacea.* Songor Ramsar Site and the eastern parts of Keta Lagoon Complex Ramsar Site. Beach recession project was undertaken along the shoreline of Keta Lagoon Complex Ramsar Site mainly to protect infrastructure and stabilized portions of the fragile beach that threatened the people and property. The beach recession project at the sampling area was selectively undertaken along worse affected beach communities. According to (Boateng, 2009), various attempts were made to halt the shoreline recession. The Keta Sea Defence Project (KSDP) was the largest and was aimed at intercepting the reduced yet significant present littoral sediment drift. Though not continuous, the isolated recession project stabilized adjoining community beaches. The groynes were located along the shoreline of sampling site 2 that recorded moderately low net mean accretion values in 2017 – 2018. The situation changed during 2018 - 2019 sampling period. A moderate mean net erosion occurred in sampling site 2, further reducing the suitability of the site for nesting turtles. The result either probably revealed the lapses in the recession project or the wave actions may have been excessively stronger within the sampling site. Erosion was normally associated with high dunes but with the completion of the project in 2004, erosion was greatly reduced as the shoreline between Keta and Havedzi was stabilized. There was a remarkable improvement in accretion in sampling site 4. The beach was extended and relatively stable and *D. coriacea* turtles nesting activities increased. This might have been influenced mainly by the presence of groynes and revetments. According to Boateng (2009), there was evidence of accretion along most sections of the coast especially west of the defence between 2001 and 2007 as a result of the construction. However, the construction of site-specific hard structures such as the Keta Sea Defence tends to stabilised a specific section of the coastline and cause a "knock on effect" down drift as confirmed by Boateng (2009), that to the immediate east of the sea defence work, erosion is occurring at high rates leading to the destruction of properties. This beach loss was, however compensated by marginal natural beach nourishment from July 2018 to September 2018. The accruing natural sand, an important beach nourishment process, normally reduced the height of the sand dunes created by erosion and provided the required suitable nesting habitat for turtles. This was evident by increased turtle nesting activities within the sampling period. Segments of the nourished beach could not be utilized by turtles for nesting due to the presence of coarse and calcareous materials in the sand along the beach. The hard engineering sea defence work has stabilised portions of the beach but they need to be maintained as some segments of the structures have disintegrated.

Conditions of Nesting Habitats and Selection of Nesting Sites by Turtles

Mean tidal line and nesting site selection

Accessibility of beach is critical for the selection of suitable nesting site and successful incubation of egg in the nest. Beach with sand dunes and scarps limited turtle access to suitable nesting sites. Two factors influenced site selection. The first is the microhabitat and the second is the macrohabitat (Spencer, 2002). The selection of suitable beach by the turtles was based on the absence of physical barriers and objects that constituted threats and possibly might have prevented them from accessing the beach. Successful location of suitable nesting sites is important therefore for the protection of turtle nest. Absence of sand dunes mostly indicated moderately improved beachfront through natural sand deposition, reduction in dune heights and extended sandy beach. Within the sampling areas, it was observed that access to the beach by turtles that emerged from the sea was limited by the presence of sand dunes, dune slopes and beach scarps. The number of turtle nesting activities recorded was significantly related to beach morphology of the sampling areas and sites. The percentage of turtle nesting activities were higher along accreted shoreline, well-nourished with moderately low to medium sand dunes. *D coriacea* and *C. mydas nests* were mostly located on or close to dunes or vegetative beach areas. Nests placed on dunes favour the embryonic development and eggs are protected from flooding.

The chances of successful turtle nesting activities within the sampling areas were directly related to fovourable beach formation. It was observed during the study that within the sampling areas beach that was nourished, extended and with low dunes were selected generally by the nesting turtles. Depending on the species, the distance of the turtle nest from the beach varied from the supralittoral and mean tidal zones. Selection of beach with suitable nesting characteristics varied with turtle species. Selected *D. coriacea* nests were mostly located below mean tidal mark. The species were normally unable to climb high sand dunes. One of the advantages of nesting above the high tidal mark is to avoid flooding during high tides. There is adequate ventilation and appropriate moisture thus avoiding egg desiccation. It was observe during the study that both the seasonal features and the beach were relevant factors that had direct influence on nesting turtles in the selection of nesting sites. Nesting turtles that fail to get the required beach extension may probably nest under compulsion below mean tidal mark, sand dunes and scarps. The successful hatching of the nest is mostly compromised.

Beach sand characteristics and nesting site selection

Sea turtles relates to terrestrial environment due to the periodic nesting by the females. Successful nesting and hatching of eggs is influenced by biotic and abiotic factors of the environment. Nesting turtle species choose nesting based on the sands' characteristics. *Chelonia mydas* nest in sands having a wide variety of textures and it was observed that the texture of the sand particle varies depending on the location of the sand on the beach. Data on sand samples collected randomly and around nest within the sampling areas indicated that 98% of turtle nests were located on fine textured sand with particle size that varied between 0.005 and 0.05µm. This was possible as turtle nest sampled were mostly located on natural accreted sand and extended beach that had sand with fine grain size. Gentle sloped beaches were observed to composed of fine sand with diversified microfauna. More animal species have been observed on the predominant light - coloured sand or on fine sand (Fretey, 2001). Abandoned and shallow turtle nests were located on coarse and dry beach sand (0.05 – 0.5 µm). Sea turtles were observed to have difficulty constructing suitable nests on beaches composed of coarse and dry sand. Nesting turtles mostly would prefer naturally accreted sandy beaches as observed from the studies. The importance of moisture, temperature, and grain size of the sand around sea turtle nest as parameters for successful incubation cannot be downplayed. Continued research on sand characteristics and the success rates of nests should be an integral part of turtle conservation activities in future.

Beach pollution and influence on nest site selection by turtles

The number of wastes on our beaches especially plastics have increased as human population also increases and this has dire consequences for marine species. The abundance and spatial distribution of plastic pollution, both on land and at sea, is increasing (Barnes et al., 2009; Jambeck et al., 2015). Plastic pollution can negatively impact animals, plants, and ecosystems all around the world. More specifically, sea turtles meet many challenges when they encounter plastic pollution in the oceans. Plastic pollutants can easily be mistaken as food, leading to the ingestion by sea turtles. Plastics could present a major threat to some species through ingestion, entanglement, the degradation of key habitats, and wider ecosystem effects (Barnes et al., 2009; Vegter et al., 2014; Gall and Thompson, 2015). Among these species are the marine turtles, whose complex life histories and highly mobile behaviour can make them particularly vulnerable to the impacts of plastic pollution. Solid waste mainly plastics, rubber, grasses, dead animals, abandoned nests and human excreta were unevenly distributed along the study area. Most of the waste located on the beach were washed ashore from the wider sea. Human excreta were extensively present in communities that were closer to the shore. Solid waste compromises the aesthetic beauty of the beach and alters the suitability of the nesting habitat of nesting turtles. The waste was mainly drifted from the western section of the study area, Tema and Accra. The drift was accelerated by storms, strong waves and floods. The beach became more littered any time one or more of these factors occurred. Seaweed (*sargassum*) were very common on the beach from June to October, peaking during the major and minor raining seasons. The occasional clean-up activities that occurred within selected segments of the shore was ineffective in reducing the overwhelming volumes of waste that comes to the shore daily. Segments of the beach that was not regularly cleaned was littered with plastics and rubbers so much that at certain period it was very difficult to see the sand on the beach. The volume of waste was observed to reduced towards the eastern section of the study area. The beach was less littered as one moves towards Keta Lagoon Complex sampling area. This was also augmented by the periodic clean up schedules of some sections of the beach. Waste impacted negatively on the nesting turtles, impeding crawling and the creation of nest. Portions of Songor Ramsar sampling site 1, were mainly littered with plastics and rubber waste, *L. olivacea* and *D coriacea* turtles nesting activities recorded within portions of these sampling areas were low. A total of 45.37% and 54.26% nesting activities occurred in sampling site 1 and 2 respectively which were relatively cleaner. Keta Lagoon Complex Ramsar sites

3 and 4 were mostly littered with plastics and rubber waste. Within Sampling site 3 nesting activities recorded were high, 35.90% (n= 168). The portion littered was very insignificant and also alluding to the fact that waste on the beach may not be the only factor limiting selection of nesting sites by turtles. Sampling site 4 rather provided direct relation between presence of waste and turtle nesting activities. Only 4.06% (n=19) nesting activities occurred, probably the lowest recorded. Though the waste could not be the only factor that limited the use of a particular segment of the beach by nesting turtles, it was observed that cleaner beaches were more suitable and well utilized by nesting turtles.

Artificial lights and nest site selection by turtles

Artificial lights along the beach have detrimental effects on migratory species such as marine turtles, particularly during the nesting season. Verheijen (1985) and Witherington (1997), reiterated the biological effects of light pollution, which are not limited to sea turtles. Turtles go through diverse ecosystem challenges when they emerge from sea to nest on the beach. One of the challenges that is not noticed very much is light pollution on the beaches. The beaches of the study areas were illuminated due to improved light supply under the National Rural Electrification Project. The beach over the years has also been eroding very fast and the distance between the coastal communities and the beach has drastically reduced, therefore, light rays from houses and streets ostensibly illuminate the beach.

Ideally, pure red light that is composed mostly of wavelengths in the red region of the visible spectrum should have been used as beach security lights.

Sea turtles apparently do not see red light and red light also does not bleach the photopigment they depend upon for night vision. There were no red lights on the beach as security or domestic light. The wattage of the various colors of lights on the beach were high and the rays were highly diffused. The beach was illuminated with high wattage bulbs (400 watts). Irrespective of the color (orange and white) the bulbs were located closer to the beach (80 - 200m). Nesting activities were low to non-occurrence within this sampling sites. Elevation influences incidence of light rays and subsequent illumination of the beach. Street and security lights located on poles that were between 5.5 - 5.9m high, produced rays that illuminated significant portions of the shoreline. Light pollution on the beaches distracted turtles. Turtles physiologically get confused, considering the bright light on the beach as day and may not emerge to nest on that particular beach. Most sea turtles nest exclusively in the night. Fresh turtle nesting activities within the sampling areas were exclusively recorded between night and dawn. Between 70% - 75% of the coastal communities within the study areas were illuminated. Turtles were not only limited to 30% - 25% of darkened beaches, but have to contend with other environmental challenges. High nesting activities of turtles occurred along darkened portions of the shoreline of the study areas. 54.62% (n=390) of nesting activities occurred within the darkened beaches within the Songor Ramsar. 64.53% (n=302) occurred within the darkened beaches of Keta Lagoon complex Ramsar site.

The nesting activities of *D. coriacea* occurred within darkened portions of the beach more than any other turtle species recorded. This presupposes that, nesting activities of *D. coriacea* mostly occurred on isolated and darkened portions of the beach. It may be possible that, the absence of light on the beach influences the selection of nesting site by *D. coriacea* that emerged from sea to nest. The number of non-nesting crawls recorded for the species were not significant. *L. olivacea* turtles that emerged on illuminated beaches failed to nest due to reasons that may include availability of light on the beaches. Unfortunately, there is no known formula that can be used to calculate the limit of light turtles can tolerate. It has been observed however, that if spectral emissions are equivalent, reducing intensity will reduce effects, and if intensities are similar, substituting less attractive sources will also reduce effects (Salmon and Witherington, 1995). It will be appropriate to reduce effects on sea turtles by manipulating both intensity and color. The use of few lights as practicable should be encouraged. Light applications should be dimmed, long - wavelength light sources (LPS, bug lights, etc.) should replace more disruptive light sources and intensity should be reduced by using lamps of minimal wattage that are housed within well-directed fixtures, aimed down and directed away from the beach. Conscious effort to reduce artificial beach illumination could expand the nesting range of nesting turtles especially the *D. coriacea*.

Natural Light Source (moon) and Nesting Turtles

The information obtained from the study was difficult to established a meaningful correlation between the occurrence of turtle nesting activities and moon phases. The trend of turtles emerging from the sea and occurrence of nesting activities on the shore was observed rather to be seasonal than related to the phases of the moon. During the study, live turtles, nesting tracks and other nesting activities were more visible with the aid of the moon light. Cornelius, 1986, however, detected a correlation between nesting cycles with specific moon phases in the *L. olivacea* and to a lesser extent in the *Carreta carreta* (Burney et al., 1991). Turtle hatchlings that emerged from the nest chamber during moon light within the Songor Ramsar sampling area unilaterally moved in different directions, however, 87.92% (n=211) of the hatchlings later reoriented their direction towards sea. Disorientation of turtle hatchlings were also observed within the Keta Lagoon Complex Ramsar sampling area with 78.78% (n=52) of the hatchlings crawled towards land. The hatchlings later reoriented and crawled back to sea. The danger of disorientation of turtle hatchlings is a longer resident period on the beach and a possible subsequent predation. Salmon and Witherington (1995) have the opinion that, the moonlight apparently has effect on the degree of sea-finding.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The study sites are two adjoining–conservation areas with considerable stretch of coastline and also noted for turtle nesting activities. The coastline has undergone tremendous modification over the years, influencing nesting patterns and survival of emergent turtles. The study was to provide scientific data necessary to enhance the management and conservation of nesting turtles and the shoreline ecosystem of the Sites.

Though it was indicated that five of the globally occurring species nested along the coast of Ghana, four were recorded during the study period and they were *L. olivacea*, *D. coriacea*, *C. mydas* and *E. imbricata*. Continual and expanded monitoring activities within the sampling areas are critical to establish species occurring along the coast. Morphometric data between species sampled differed, whiles the size among the turtles sampled did not differ. This indicated that diverse size and age of turtle species are found in the Ada and Keta Ramsar sites.

Out of the 2,029 total turtle activities recorded 1,397 of the activities, which constitute 68.9%, occurred within the Songor Ramsar sampling area while 632 of the activities, which constituted 31.1%, occurred in the Keta Lagoon Complex Ramsar sampling area. Activities of *L. olivacea* were common and well distributed along the sampling areas with density of 12.5 activity per kilometre. Within Songor Ramsar sampling area 810 *L. olivacea* activities which constituted 39.9% of total turtle activities dominated the activities of species sampled.

A total of 1,183 crawling gaits and nests were recorded during the period constituting 58.3% of total turtle species activities. Of these, 579 were nest crawls, 25 non-nesting crawls and 579 nest spots. 714 turtle crawls and nest were recorded in the Songor Ramsar sampling area, constituting 60.4% of total turtle crawls and nest. This comprised 251 *L. olivacea* crawls and nests, 10 *C. mydas* and 453 *D. coriacea*. Spatial distributions of species nests were influenced by physical nature of the shoreline. *L. olivacea* nests were densest during the 2017 - 2018 sampling period with a density of 2.1/km^2. *D. coriacea* turtle species was 1.83/km^2 whiles *C. mydas* was 0.1/km^2. During the 2018 - 2019 sampling period, *D. coriacea* turtle species was densest with a value of 3.8/km^2, *L. olivacea* was 0.5/km^2, whiles *C. mydas* was 0.03/km^2. Within the Keta Lagoon Complex Ramsar area 468 turtle crawls and nest were recorded and this constituted 39.6% of the total crawls and nest. Out of these 102 were *L. olivacea* crawls and nests, representing 21.8% of nest recorded, while 366 were *D. coriacea* constituting 78.0%. *D. coriacea*. The nests were densest in 2018 - 2019 and 2017 - 2018 with a density of 2.49/km^2 and 4.0/km^2 respectively. *L. olivacea* had a density of 0.34/km^2 during 2017 - 2018 sampling period and 0.68/km^2 during 2018 - 2019.

Successful nest hatching was dependent on the emplacement of the nest on environmentally appropriate sites by nesting turtles. Nests that were strategically placed by nesting turtles within suitable selected nesting sites successfully hatched. Within Songor Ramsar sampling area 19 successful hatched nests were encountered comprising 12 *L. olivacea* and 7 *D. coriacea* hatched nests. In Keta Lagoon Complex Ramsar area 14 hatched nests were recorded which comprised of 9 Olive ridley turtle *(L. olivacea)* and 5 *L. coriacea* hatched nests respectively.

Emerging hatchlings from successfully hatched turtle nests varied between species. In Songor Ramsar sampling area 240 hatchlings emerged comprising 151 *L. olivacea* and 89 *D. coriacea* hatchlings. Within the Keta Lagoon Complex Ramsar area, 48 *L. olivacea* and 18 *D. coriacea* hatchlings were recorded.

Poaching of stranding and nesting turtles and turtle eggs were a major concern within coastal communities. Turtles that emerged from sea face diverse threats in the wider sea and in the nesting environment. Some nesting turtles were poached along the beach in the sampling areas mostly during the nesting seasons. Within Songor Ramsar sampling area 4 *L. olivacea* were poached, representing 6.15% of total poached turtles. The result indicated a monthly poaching rate of 0.133 and an annual rate of 0.024 for the area. In Keta Lagoon Complex Ramsar, 61 turtles representing 93.85% of total poached turtles, comprising 9 *L. olivacea* representing 13.85%. 52 *D. coriacea* constituted 80% of total poached turtles and this indicate a monthly poaching rate of 2.03 and annual poaching rate of 0.37. Poaching of turtles that emerge from sea to nest in Keta Lagoon Complex Ramsar area was a major challenge that requires adequate effort from all stakeholders to minimize the occurrences.

Turtle deaths from the wider sea was observed to have the potential to decimate population of sea turtles. The deaths may be linked to unsustainable fisheries activities. What was alarming was the death rate of higher number of female turtles. A total of 545 turtle deaths were recorded which constituted 26.86% of the total turtle activities. Turtle deaths recorded decreased eastward of the sampling area. Within Songor Ramsar sampling area, 534 turtle deaths representing 97.98% was recorded comprising 430 *L. olivacea* , 98 *C. mydas,* 5 *D. coriacea* and a *E. imbricata.* Comparatively, 11 turtle deaths were recorded along the Keta Lagoon Complex Ramsar sampling area, representing 2.01% of the total turtle deaths recorded. Of these, 7 *L. olivacea*, 1 *C. mydas* and 3 *D. coriacea* were recorded respectively. The Sex of the dead turtles varied among the species. Of the 534 dead turtles sampled, 113 were males, which constituted 20.7% of dead turtles sampled, 330 (60.5%) were females, while 102 (18.7%) were indeterminates. Intense fishing activities during the turtle nesting season and non - compliance of the use of TED (Turtle Excluder Device) may be one of the causes of high turtle deaths.

Turtle nest predation along section of the beach of the sampling area was unusually alarming as feral dogs, pigs, ghost crabs and human emptied nest of turtle species. A total of 121 nests predatory activities occurred within the Songor Ramsar sampling area which represented 64.0% of total nest predatory activities, whiles 68 occurred in the Keta Lagoon Complex Ramsar sampling area which represented 36.0% of total nest predatory activities. *L. olivacea* nests were most vulnerable to predation due to shallow nest and mostly incomplete nest obliterations. There were no recorded dog predations of *D. coriacea* nests as the species usually dug nest of considerable depth that was well obliterated and mostly concealed from predators.

The nesting habitat of the turtles was highly unstable during the sampling period. Assessment of the beach morphodynamics revealed significantly varied beach erosion, accretion and sand dunes within the sampling areas. The intensity of landscape changes was very visible along the coastlines, which has no sea recession interventions.

Within Songor Ramsar Site a marginal net erosion of 1.07m was recorded within sampling site 2 during 2017 - 2018 whiles a net accretion of 21.2m was recorded at sampling site 2. Corresponding sand dunes created by excessive waves were high in the months of July (0.52m), August 2017 (0.67m), February 2018 (0.48m) and March 2018 (0.42m). Within Keta Lagoon Complex Ramsar site a marginal net mean erosion of 0.71m occurred in sampling site 2, whiles a net marginal accretion of 15.85m was recorded at sampling site 1 during 2018 - 2019 sampling period. The changes along the shoreline affected the nesting pattern of turtles. The number of turtles that emerged from sea and turtle nesting activities were usually seen on the shore when the sand dune was low, however, nesting activities were observed to be low or non-existence during period of high sand dunes. Generally, turtles that emerged from sea to nest and nesting activities recorded were relatively low when erosion was high. Accretion was observed to be a profound seasonal beach nourishment process that lowers the height of sand dunes and enhanced the accumulation of natural sand on the beach. High accretion periods were characterised by high turtle nesting activities. Though accretion was high in October, it was generally observed to be characterised by low turtle nesting activities even though the shoreline was adequately conducive. The period was observed to signify a dip in nesting activities of *L. olivacea* and the onset of the nesting period of *D. coriacea*.

Diverse habitat selection pattern were exhibited by most nesting turtles. Intuitively, most nesting turtles will normally nest where natural sand has accreted enough on the beach for them to dig to get the required nest depth. However, some local conditions such as undesired artificial lights, high sand dunes, calcareous nourished sand and rock boulders from sea recession projects affected the use of some nesting sites along the beach. Within Songor Ramsar sampling area out of 321 turtle nests sampled, 315 nests were located on natural accreted sandy beach whilst 6 occurred on the nourished sand. In the Keta Lagoon Complex Sampling area 266 turtle nests occurred on the natural accreted sandy beach. Natural accreted beach had fine textured sand with granulometric average size between 0.005 and 0.05µm. Turtle nests sampled on the natural sand had an average depth between 42.0 and 60.0cm for the *L. olivacea*, 90.0 and 120.0cm for *D. coriacea* and 65.0 and 80.0cm for the *C. mydas.*

Distance of turtle nest from mean tidal mark varied with species recorded. Within Songor Ramsar sampling area the average nest distance of *L. olivacea* turtle was between 4.7m and 38.6m, *D. coriacea* was (-10) and 38.0m and *C. mydas* 5.5m and 19.4m. Within Keta Lagoon Complex sampling area *L. olivacea* nests were located between (-14.0) and 154.0m from the highest tidal mark and *D. coriacea* nests were located between (-55.0) and 110.0m.

Substrate under natural beach was basically clay, calcareous sand and laterite that was located within depths between 55.0m and 120.0cm. Nourished beach had dredged sand that was coarse textured and had grain size between 0.05µm and 0.5µm. Turtles occasionally abandoned nesting process when they could not dig the sand on the nourished beach. Occasionally, shallow nests with depth between 15.0m and 20.0cm were created. These nests were mostly created by *L. olivacea.* Clay, calcareous sand and laterite substrates limited digging by turtles to attained the required nest depth, which renders the nest vulnerable to predators and hazardous weather conditions.

Plastic materials were common waste that mainly occurred and dominated the beach of the sampling areas. There were other waste materials, which included rags, abandoned nets, human excreta that were common on the beach of the coastal communities. The sources of the waste were diverse. Waste compromises the aesthetic beauty of sandy beaches and was observed to interfere in turtle nesting processes.

Illumination of the beach influenced selection of nesting site by turtles. Some lights were consciously orientated to illuminate the beach (security lights). It was observed that the extent of illumination of the lights depended on the wattage and colour. The wattage of the street and security lights varied. Lights were mounted at a particular elevation to enhance illumination. Illuminations of the beach by security, street and domestic lights had implications on turtles that emerged from sea to nest. Over 75% of turtle nesting activities encountered during the sampling periods were located within darker and isolated beaches. Efforts to minimise beach illumination will improve nesting condition of turtles that emerge to nest along the beach.

Recommendations

To enhance turtle identification, data collection and information sharing to protect nesting turtles, the study recommends that the Wildlife ***Division of the Forestry Commission should:***

1. Developed species identification manual and distribute to key stakeholders involved in turtle conservation programs.

2. Develop standardized data collection protocol that can easily be adopted and used for basic data collection for a sustainable monitoring system and improve understanding of global population trend.

To reduce poaching of stranded and nesting turtles it is recommended that;

1. Modern tools such as satellite telemetry, camara traps and drones which provide superior means of long-distance monitoring are employed to enhance the protection of turtle species.
2. Collaborate with traditional authorities to enforce existing traditional norms that protect turtles.
3. Build capacity of Community Resource Management Committees (CRMC) to collect data and protect nesting turtles

To reduce depredation of turtle nest during nesting period it is recommended that:

1. Nest management strategies is designed and implemented to achieve the required 70% successful hatched nest standard, as recommended by IUCN.

2. Beach illumination is minimized drastically near nesting beaches to encourage turtle nesting activities.

3. Nesting beaches and near shore habitats used by nesting turtles within the coastal Ramsar sites are protected through extended law enforcement patrols.

To reduce the effect of shoreline changes and sea recession projects on nesting turtles, it is recommended that:

1. Ghana's shoreline change maps and data is reviewed to understand the degree of shoreline changes to support national turtle conservation efforts.

2. Further studies which cover greater segment of nesting beach, would provide a clearer picture of the threat shoreline changes and beach loss pose to nesting turtle population.

Recommendation for communication to among stakeholders to protect nesting turtles;

1. The Wildlife Division should undertake at all levels education, communication and awareness creation on the protection of the species that can generate interest and survival of the species that were suspected to be endangered.
2. Fishing communities should be educated on the use and benefits of TEDs, which include increased longevity of fishery stocks, a decrease in unwarranted by-catch and general marine conservation.

Recommendation for involvement of stakeholders to protect nesting turtles;

1. The Division should support the formation of Community Resource Management Areas (CREMA), a conservation process that is strengthen within the legal and institutional frameworks that govern the access and use of natural resources including turtles.

REFERENCES

Ada East District Assembly [AEDA], (2022). Medium Term Development Plan. 26-35

Agyeman, D. Y., Riverson S. A., & Agyekumhene A. (2013). *Nesting ecology and conservation of nesting turtles in Songor Biosphere Reserve.* AFRIMAB- Biosphere Reserves in Sub-Saharan Africa: Showcasing Sustainable Development, 246 – 254

Agyeman D. (2008). Socio-Cultural and Environmental Factors Influencing the Nesting and Conservation of Marine Turtles in Songor Ramsar Site, A thesis submitted to the Environmental Science Programme, University of Ghana. 34-38

Amate, C. O. C. (1999). The making of Ada. 11-18

Appeaning-Addo, K., Jayson-Quashigah P.N., & Kufogbe K. S. (2011). Quantitative Analysis of Shoreline Change Using Medium Resolution Satellite Imagery in Keta, Ghana. *Marine Science* 2011, Vol 1(1): 1-9 DOI: 10.5923/j.ms.20110101.01

Appeaning-Addo, K. (2009). Detection of Coastal erosion hotspots in Accra, Ghana. Journal of Sustainable Development in Africa, 253-258

Arturo, H., & Dubose G. (2009). Sea Science. An Information/Education Series from the Marine Resource Division. South Carolina Department of Natural Resources, 1-4

Ariza, E., Jiménez, J.A., Sardá, R. (2008). A critical assessment of beach management on the Catalan coast. Ocean Coast Management 51. 141–160

Aureggi, M. (2003b) Conservation assessment of sea turtle nesting beaches of Belek, Turkey. Report of the 23rd Meeting of the Standing Committee of the Bern Convention. T-PVS/File ((2003). 15

Barbosa, C., Broderick, A., & Catry, P. (1988). Marine turtles in the Orango National Park (Bijago Archipelago, Guinea – Bissau). Marine Turtle Newsletter, 81: 6-7

Barnes, D. K. A., Galgani, F., Thompson, R. C., & Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society B, 364, 1985 – 1998

Bjorndal, K. A. (1982). Biology and Conservation of Sea Turtles, Smithsonian Institution Press, Washington, D.C. (1982), 139-142

Bjorndal, K. A., & Bolten A. B. (1992). Spatial distribution of Green turtles (*Chelonia mydas*) nests at Tortuguero, Costa Rica. Copeia 1992, 45-53.

Bjorndal, K. A., & Bolten, A. B. (1988). Growth rates of immature green turtles, Chelonia mydas, on feeding grounds in the southern Bahamas. Copeia 1988, 555-559

Bjorndal, K. A., & Bolten, A. B. (1989). Comparison of straight line and over-the-curve measurements for growth rates of green turtles, Chelonia mydas. Bulletin of Marine Science 45, 189-192

Boateng, I. (2009). Development of Integrated Shoreline Management Planning: A Case Study of Keta, Ghana. Proceedings of the International Federation of Surveyors Working Week, May 3rd- 8th, Eilat, Israel. Retrieved August 11, 2010 from http://www.fig.net/pub/fig2009/papers/ts04e/ts04e boateng_3463.pdf

Bolten, A. B. (1999). Techniques for Measuring Sea Turtles. Archie Carr Center for Sea Turtle Research, Department of Zoology, P. O. Box 118525, University of Florida, Gainesville, Florida., 4-9

Booth, D.T., & Astill, K. (2001). Temperature variation within and between nests of the green sea turtle, Chelonia mydas (Chelonia: Cheloniidae) on Heron Island, Great Barrier Reef. Austrailian Journal of Zoology, 49(1), 71-84

Bowen, B. W., Clark, A. M., Abreu-Grobois, F. A., Chaves, A., Richart, H. A., & Ferl, R. J. (1998). Global Phylogeography of the ridley sea turtles (Lepidochelys spp) as inferred from mitochondrial DNA sequences. Genetical, 101, 179-189

Brongersma, L. D. (1982). Marine Turtles of the Eastern Atlantic Ocean, 407-416 in Biorndal, K. A. eds. Biology and Conservation of Sea Turtles. Smithsonian Inst. Press, Washington D. C., and WWF, 583

Brooke, M., DE L., & Garnett, M. C. (1983). Survival and reproductive performance of hawksbill turtles (*Eretmochelys imbricata*) on Cousin Island, Seychelles. Biological Conservation 25, 161–170

Brown, A. C., McLachlan, A. (2002). Sand shore ecosystems and threats facing them: some predictions for the year 2025. Environment Conservation 29, 62–77

Burney, C. M., Mattison, C., & Fisher L. (1991). The relationship of loggerhead nesting patterns and moon phase in Broward County, Florida, 161–164 in Richardson, T. H., Richardson, J. I., & Donnelly, M., eds. Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS– SEFC–278.

Calabrese, C. (2019). Tracking Down Species Identification. http://myfwc.com / media/201274/CRAWL_Identification_Guidelines.pdf. Retrieved 15th September, 2020

Cansdale, G.S (1955). Reptiles of West Africa. Penguin Books. London. West Africa series. 3-6

Campbell, A M., & Godfrey, M. H. (2002). Community-Based Conservation via Global Legislation. Limitations of the Inter-American Convention for the Protection and Conservation of Sea Turtles Journal of International Wildlife Law and Policy, 5: 121–143 (2002) 2002 Kluwer Academic Publishers. Printed in the United States. pp 13-17

Carr, A., & Ogren L. (1995). The ecology and migrations of sea turtles. Dermochelys in Costa Rica. American Museum Novitates 1958:, 1–5

Carr, A. (2022). Sea turtle conservancy. https://conserveturtles.org/sea-turtle-conservancy/. 1 - 4. Retrieved August, 2022

Carr, T., & Campbell, C. L. (1995). A management Strategy outline for marine turtle conservation in Ghana. Survey of the Sea Turtles of Ghana. Report to the Wildlife Department, Republic of Ghana, 23

Carr, T., & Carr, N. (1991). Surveys of the sea turtles of Angola. Biological Conservation, 58, 19–29

Coastlearn. (2016). Principles of ICZM. Retrieved December 13, 2017 from 2016http://www.coastlearn.org/intro/introduction.html

Crain, D.A., Bolten, A.B., Bjorndal, K.A., (1995). Effects of beach nourishment on sea turtles: review and research initiatives. Restoration. Ecological. 3, 95–104

Dankwah, H. R., Abban E. K., and Tuegel G. G. (1999) Freshwater Fisheries of Ghana, identification, Distribution, Ecological and Economic importance. 7

Demetropoulos, A. (2000). Impact of tourism development on marine turtle nesting: strategies and actions to minimize impact: Conventions on the Conservation of European Wildlife and Natural habitats, Strasbourg, 6 September 200. Council of Europe. 42

Derek, S. (2012). Journal of the South African Institution of Civil Engineering Vol. 54 No. 2, Midrand Jan. 2012, 5-13

Desmond, O. A., Philip N. N., & Macpherson D., (2013). A rapid overview of coastal erosion in Ghana. International Journal of Scientific & Engineering Research Volume 4, Issue 2, February-2013. 1 ISSN 2229-5518

Dominique, M. (2014) HuffPost, Environment. Retrieved December 21, 2016. http://www.huffingtonpost.com, 5-13

Eckert, K. L., Bjorndal, K.A., Abreu-Grobois, F. A., & Donnelly, M. (1999). Research and management techniques for the conservation of sea turtles. Smithsonian Institution Press, Washington, D.C. (1999), 522-528

Ekert, S. A. (1999). Global distribution of juvenile Leatherback sea turtles. Hubbs Sea World Research Institute Technical Report 99-294, 13

Jonah, F.E., Agyekumhene, A., Boateng, I., & Shimba, M.J., (2016)

Preliminary Assessment of Sea Turtle Conservation Issues in the Cape Coast Area of Ghana. GECCO 2016. 149

Food and Agriculture Organisation [FAO] (2004). Fisheries Report No. 738, Supplement – papers presented at the Expert Consultation on Interactions between sea turtles and fisheries within an ecosystem, 1-23

Feagin, R. A., Smith, W.K., Psuty, N. P., Young, D. R., Koske, R. E. (2010) Barrier Islands: coupling anthropogenic stability with ecological sustainability. 26, 987–990

Fish, M. R., Côte, I. M., Gill, J. A., Jones, A. P., Watkinson, A. R. (2005). Predicting the impact of sea-level rise on Caribbean sea turtle nesting habitat. Conservation Biology. 19, 482–488

Fretey, J. (2001). Biogeography and conservation of marine turtles of the Atlantic coast of Africa. CMS Tech. Series Publication. No. 6, 426

Gall, S. C., & Thompson, R. C. (2015). The impact of debris on marine life. Marine Pollution Bulletin. 92, 170–175

Gawler, M., & Agardy, T. (1994). Developing WWF process for marine in the Africa & Madagascar Region. WWF and Africa and Madagascar subcomm and WWF Marine Academy Group, 67

George, F. V.V. & Kazakov. A. (2016). Grain Size Analysis Encyclopedia of Geoarchaeology DOI:10.1007/978-1-4020-4409-0_18(pp.341-348)

Groombidge, B. & Luxmore, R. (1989). The green turtle and the hawksbill, world status, exploitation and trade. CITES Secretariate. 45

Ghana Man and Biosphere National Committee [MAB] (2010). Ecological Mapping of the Songor Biosphere Reserve. 12-24

Ghana Man and Biosphere National Committee [MAB] (2016). Management Plan 2016 – 2021. Songor Ramsar Site and UNESCO Biosphere Reserve. 23

Great Lakes Dredge and Dock Company [GLDD] (2001). Keta Sea Defence: Protecting a Fragile Eco- system and the Communities it Supports. Retrieved December 10, 2010, from http://www.gldd.com/images/ Static/ OurProjects_1_2-2.pdf

Hailman, J. P., & Elowson A. M.. (1992). Ethogram of the nesting female loggerhead (Caretta caretta). Herpetological 48, 1–8

Hanson, H, Brampton, A., Capobianco, M., Dette, H. H., Hamm, L., Spanhoff, R. (2002). Beach nourishment projects, practices, and objectives - an European overview. Coastal Engineering, 47, 81-111

Harvey, M. (2018). WWF. http://wwf.panda.org/knowledge_hub/endangered _species/marine_turtles/leatherback_turtle/. Retrieved August 2018

Hays, G. C., Mackay, A., Adams, C. R., Mortimer, J. A., Boerema, M. (1995). Nest site selection by sea turtles. 75, 667−669

Hays, G. C., Mackay, C. R., Adams, J. A., M. Boerema. (1995). Nest Site Selection by Sea Turtles. Journal of the Marine Biological Association of the United Kingdom 75, 667-671

Hirth, H. F., & D. A. Samson. (1987). Nesting behavior of green turtles (*Chelonia mydas*) at Tortuguero, Costa Rica. Caribbean Journal of Science 23, 374–379

Holgate, S. J. (2007). On the decadal rates of sea level change during the twentieth century. Geophysical Research Letters, 34, L01602, 1- 4

Houghton, J. D. R., Myers, A. E., Lloyd, C., Hays, G. C. (2007). Protracted rainfall decreases temperature within leatherback turtle (*Dermochelys coriacea)* clutches in Grenada, West Indies: ecological implications for a species displaying temperature sex determination. 345, 71−74

Huges, G., Huntley, B., & Wearne, D. (1973). Sea turtles in Angola. Biological Conservation. 5 (1): 58-59

Huges, B. (1988). Herpetology in Ghana (West Africa). Britain Herpetology Society Bulletin, 25, 29-33

Hutchinson, J. & Simmonds, M. (1991). A review of the effects of pollution on marine turtles. Thames Polytechnic, London. A Greenpeace ecotoxicology projects. 20. Retrieved, September, 2017

International Panel on Climate Change [IPCC] (2017). The Regional Impact of climate change. htpp://www.ipccreports/sres/regional/index.php?idp =30. 3-4. Retrieved, October 2017

IUCN. (1995). Marine Turtle Specialist Group, A Global Strategy for the Conservation of Marine Turtles, 2-6

Jackson, N. L, Nordstrom, K. F., Saini, S., & Smith, D. R. (2010). Effects of nourishment on the form and function of an estuarine beach. Ecological Engineering 36, 1709–1711

Jacques F. (2001). Biogeography and Conservation of Marine Turtles of the Atlantic Coast of Africa. Conservation of Migratory Species. 192 – 195

Jacques, F. & Triplet, P. (2022). Training Manual for the Conservation of marine turtles in West Africa. 25 – 87

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R. Narayan, R. (2015). Plastic waste inputs from land into the ocean. Science 347, 768–771

James, R.J. (2000). From beaches to beach environments: linking the ecology, human-use and management of beaches in Australia. Ocean Coast Management 43, 495–514

Jean-Jacques, G., & Mathieu D. (2014). West African Coastal Area: Challenges and Outlook. 1-16

Jeanette, W. (1997). Sea Turtle Locomotion: Mechanism, Behavior and Energetics. CRC Press. Inc. 165 – 167

John, D. M., & Lawson, G. W. (1991). Littoral ecosystems of tropical Western Africa. 297-321 in: Mathieson & Nienhus (Eds). Intertidal and littoral ecosystem. Elsevier 24, 1-3

Jonas, F. K., Abeashi, M. E., Edziyie E. R., Agbo, N. W., & Adjei-Boateng, D. (2016). Coastal Erosion in Ghana: Causes, Policies, and Management, Coastal Management, 44:2, 116-130, DOI:

Kama, D. (2005). Marine Turtle Newsletter, April 2005, No. 105, 26-27

Kasperek, M. (2003). Conservation status of green turtles *(Chelonia mydas)* in the Mediterranean: Karzanli, Akyatan, Samadag(Turkey). Report of the 23rd Meeting of the Standing Committee of the Bern Convention. T-PVS/Files (2003) 14:9

KEMA, (2022). Keta Municipal Assembly Medium Term Development plan. 35 - 40

Kolbe, J. J., Janzen, F. J. (2002). Impact of nest-site selection on nest success and nest temperature in natural and disturbed habitats. Ecology 83, 269–271

Leighton, P. A., Horrocks, J. A., & Kramer, D. L. (2010). Predicting nest survival in sea turtles: when and where are eggs most vulnerable to predation? Animal Conservation. 2010;14:.doi:10.1111/j.1469-1795. 2010.00422.x. 186–189

Leonel, Z. & Jorge E. M. (2013). Nest site selection by the green turtle (*Chelonia mydas*) in a beach of the north of Veracruz, Mexico. Revista Mexicana de Biodiversidad 84, 927-930

Limpus, C. J. (2008). A Biology Review of Australian Marine Turtles. Loggerhead Turtle (*Caretta caretta*) (Linneaus) (2008) (Brisbane, QLD). 13

Lohmann, K. J., M. Salmon, and J. Wyneken (1990). Functional autonomy of land and sea orientation systems in sea turtle hatchlings. Biological Bulletin 179. 214–218

Loveridge, A., & Williams, E. E. (1957). Revision of the African tortoises and turtles of the suborder Cryptodira. Bull Museum 115 (6), 163- 167

Ly, C.K. (1980). The Role of the Akosombo Dam on the Volta River in Causing Coastal Erosion in Central and Eastern Ghana (West Africa). Marine Geology. 37.

Lyster, S. (1985). International Wildlife Law, An Analysis of International Treaties concerned with the conservation of wildlife, 279-280

Magane, S., Sousa, L., & Pacule, H. (1998). Summary of turtles and Fisheries resources for Mozambique. In G.M. Wamukoya & R.V. Salam, eds. Report of the Western Indian Ocean Turtle Excluder Device (TED) Training workshop, Mombasa, Kenya, January 1997, Nairobi, IUCN East Africa Regional Office, 18-20

Maison, K.A., King, R., Lloyd, C. & Echert, S. (2010). Leatherback nest distribution and beach erosion pattern at Levera Beach, Grenada, West Indies. Marine Turtle Newsletter 127, 9–11

Manger, M. (1985). Status review, Marine turtles under Jurisdiction of the Endangered Species Act of 1973. National Marine Fisheries Service, NOAA mimeograph, 64

Mazaris, A. D., Matsinos, G., & Pantis, J. D. (2009). Evaluating the impacts of coastal squeeze on sea turtle nesting. Ocean Coast Management 52, 139−141

Mazaris, A. D., Vokou, D., Almpanidou, V., Türkozan,, S.P. (2015). Low conservatism of the climatic niche of sea turtles and implications for predicting future distributions. Ecosphere 6, 1–5

Meehl, G., Tebaldi C., Hayhoe K, & Arblaster J., (2006). Going to the extremes Climate Change 79 (3), 185–211

Miller, J. D. (1985). Embryology of marine turtles. In Biology of the reptilian, volume 14, Gans, A., Billett, C., & Madreson, P. F. A. (eds.). Wiley-Inter science, New York, 269

Ministry of Lands, Forestry and Mines [MLFM] (1998). Ghana National Wetlands Strategy. Wetlands Fauna Diversity Information Study. 37.

Ministry of Environment and Water Resources [MEWR] (2014). Draft Policy Framework Integrated Coastal Zone Management Steering Committee, 6-10.

Moore, L. J., Benumof, B. T., & Griggs, G. B. (1999). Coastal Erosion Hazards in Santa Cruz and San Diego Counties, California, J. Coastal International Journal of Scientific & Engineering Research. Vol. 4, Issue 2, February-2013 7 ISSN 2229-5518, 23-25.

Mortimer, J. A. (1982). The influence of beach sand characteristics on the nesting behaviour and clutch survival in green turtles. In: Bjomdal K, (ed.) The Biology and Conservation of Sea Turtles. Smithsonian Institute Press Washington D.C, 21

Morton, R. A., & McKenna K. K. (1999). Analysis and Projection of Erosion Hazard Areas in Brazoria and Galveston Counties, Texas', Journal of. Coastal Research, 28, 106–120

Morton, R. A., & Sallenger, A. H., (2003). Morphological impacts of extreme storms on sandy beaches and barriers. Coastal Resources 19, 560−563

Nicholls, R. & Tol R. (2006). Impacts and responses to sea-level rise: a global analysis of the SRES scenarios over the twenty-first century. Philoso Trans A 364 (1841), 1073.

Ofosu, A. D., Nkrumah, N. P., Macpherson, N., & David, A. (2013). Rapid Overview of Coastal Erosion in Ghana. International Journal of Scientific & Engineering Research. Vol 4, February-2013, 1 ISSN 2229-5518, 2-6.

Patino-Martinez, J., Marco, A., Quiñones, L., & Hawkes, L. A. (2014). The potential future influence of sea level rise on leatherback turtle nests. 461, 116−118.

Pike, D.A., Roznik, E.A., Bell, I. (2015). Nest inundation from sea-level rise threatens sea turtle population viability. R. Soc. Open Sci. 2. 150127.

Ramsar Convention Bureau. (1997). A guide to the Convention on Wetlands. The Ramsar Convention manual 2nd Edition. Ramsar information paper # 14., 3-12

Rivas, M. L., Fernández, C., & Marco, A. (2016). Nesting ecology and population trend of leatherback turtles Dermochelys coriacea at Pacuare Nature Reserve, Costa Rica. Oryx 50, 274−279

Salmon, M., and B. E. Witherington. (1995). Artificial lighting and seafinding by loggerhead hatchlings: Evidence for lunar modulation. Copeia 1995, 931–938.

Scott B., Bjondal K. A., Bolten A. B., & Bowen B. W. (2007). State of the world's sea turtles (SWOT). Report vol 7, 14-18

Scott, B., Bjondal K. A., Bolten A. B., & Bowen B. W. (2009). State of the World's Sea Turtles (SWOT) Report, Vol V, 37

Spencer, R. J. (2002). Experimentally testing nest site selection: fitness trade-offs and predation risk in turtles. Ecology 83, 2136-2144, 11-13

Spotila, J. R., Dunham, A. F., Leslie, A. J., Steyermark, A. C. Paladino, F. V. (1996). Worldwide population decline of *Dermochelys coriacea*: are leatherback turtles going extinct? Chelonian Conservation Biology. 2, 209 – 211

Stancyk, S. C. (1995). Non-human predators of sea turtles and their control. In: Bjorndal KA, editor. Biology and conservation of sea turtles. Smithsonian Institution Press; Washington, D.C. 1995, 139–141

Stuart, S, N., & Adams, R. J. (1989). Biodiversity in Africa and its islands. Its Conservation, Management and Sustainable Use. IUCN / WWF / ICBP / Conservation International, 145

Stuart, S. N., Adams, R. J., & Jekkins, M. D. (1990). Biodiversity in Sub-Saharan Africa and its Islands. Conservation, Management and Sustainable Use. Occas. Paper IUCN Species Survival Commission, 6, 1- 4

Steiner, T. (2022). Turtle Island Restoration Network, SeeTurtles.org Global Patterns of Illegal Marine Turtle Exploitation. 1-2

Suraphol, S. (1999). Ocean and coastal management - who and what is to be involved in successful coastal zone management: a Thailand example, 41-43

Tisdell, C., & Wilson C. (2002). Ecotourism for the survival of sea turtles and other wildlife. Biodiversity and Conservation 11:1521 – 1525

Thomson, J.A., Gulick, A., Heithaus, M.R. (2015). Intraspecific behavioral dynamics in a green Turtle *Chelonia mydas* foraging aggregation Marine Ecology Progress Series 532:243–256

Toth, E. F., & Toth, K. A. (1974). Coastal national park site selection survey of Department Game and Wildlife, unpublished report

Troëng, S., Chacon, D., & Dick, B (2004) Possible decline in Leatherback turtle *Dermochelys coriacea* nesting along the coast of Caribbean Central America. Oryx 38, 395–398

Udo, K., Takewaka, S., & Nishimura, H. (2002). Long- term morphological change of backshore dunes. Proceedings, 28th International Coastal Engineering Conference, Cardiff, Vol 3, 3786-3798

United Nations. (2014). United Nations Open Working Group. Outcome Document – Open Working Group on Sustainable Development Goals. MDG Momentum. Retrieved 15 June 2017 from http://www.un.org/millenniumgoals/mdgmomentum.shtml

United Nation Environment Program [UNEP]/ Convention on Migratory Species [CMS] (2000). Conservation Measures for Marine Turtles of the Atlantic Coast of Africa. CMS Technical Series Publication No.5, UNEP/CMS Secretariat, Bonn, Germany. 23-27

United States Fish and Wildlife Service (2020). https://www.bing.com/search?q=us+fish+and+wildlife+website&FORM=QSRE1.13-15 Retrieved October 2020.

Van Dam, R., & Diez, C. E. (1994). Foraging ecology and population dynamics of the hawksbill (Eretmochelys imbricata) at Mona Island, Puerto Rico: Research report for 1993. Unpublished. 26

Vegter, A., Barletta, M., Beck, C., Borrero, J. Costa, M. (2014). Global research priorities to mitigate plastic pollution impacts on marine wildlife. Endangered Species Research, 25, 225–227.

Venizelos, L., & Smith, M. (1997). The impact of small garbage on the marine environment with emphasis on the Mediterranean marine turtle population. Coastlines 97 (EUCC) Naples, 2-6 June 1977. 6

Verheijen, F. J. (1985). Photo pollution: artificial light optic spatial control systems fail to cope with. Incidents, causations, remedies. Experimental Biology 44, 1–8.

Wildlife Division, (2002). Consolidated Wildlife laws of Ghana, 2nd Edition. Wildlife Division Forestry Commission, 49-53

Wildlife Division, (1999). Keta Lagoon Complex Ramsar Site Management Plan. 23 - 35

Wildlife Division, (1999). Wetlands Management (Ramsar Sites) Regulations, 1999. L.I 1659. 1-2

Witherington, B. E. (1992a). Behavioral responses of nesting sea turtles to artificial lighting. Herpetological 48, 31–33

Witherington, B. E. (1997). The problem of photo pollution for sea turtles and other nocturnal animals. 303–328 in J. R. Clemmons and R. Buchholz, eds. Behavioral Approaches to Conservation in the Wild. Cambridge University Press, Cambridge, England

Witherington, B. E., Kubilis, P., Brost B., & Meylan, A.B. (2009). Decreasing annual nest counts in a globally important loggerhead sea turtle population. Ecological Applications 19 (1), 30-35

Witherington, B., Bresette, M., Herren, R. (2006a). Chelonia mydas - Green Turtle In Biology and Conservation of Florida Turtles. Meylan, P.A. (Ed.). Chelonian Research Monographs, Lunenburg, Massachusetts, USA, 90 – 97

Witherington, B., Herren, R. & Bresette, M. (2006b). *Caretta caretta* - Loggerhead Sea Turtle. In Biology and Conservation of Florida Turtles. Meylan, P.A. (Ed.). Chelonian Research Monographs, Lunenburg, Massachusetts, USA, 74–79

World Bank Report. (1996). Towards an integrated coastal zone Management Strategy for Ghana, 1-15

Zanuttigh, B., Martinelli, L., Lamberti, A., Moschella, P., Ceccherelli V. U., (2005). Environmental design of coastal defence in Lido di Dante, Italy. Coastal Engineering, 52, 1089-1125

Zhang, K., Whitman, D., Leatherman, S. & Robertson, W. (2005). Quantification of beach changes caused by hurricane Floyd along Florida's Atlantic Coast using airborne laser surveys. Journal of Coastal. Resources, 21, 123–127

Zhang, Y., (2010). Coastal Environmental Monitoring using Remotely Sensed Data and GIS Techniques in the Modern Yellow River Delta, China. Environmental Monitoring Assessment, DOI: 10.1007/s10661-010-1716-9

APPENDICES

Appendix 1: Total activities recorded in the sampling areas - 2017 - 2019

Year / Sampling Area	Species / activities														
2017/2018	live	stranding	dead	nest crawls	non nest crawls	nest spots	nest predation	USPA	poached	by-catch	Rescued	hacthed nest	disorient	reorient	Totals
Ada - SRS	1	0	213	161	15	161	62	4	2	0	0	14	0	0	633
Keta - KLCRS	1	2	4	83	1	83	14	0	20	0	1	6	0	0	215
Sub -total	2	2	217	244	16	244	76	4	22	0	1	20	0	0	848
2018/2019															
Ada - SRS	2	0	321	186	5	186	52	3	2	0	0	5	1	1	764
Keta - KLCRS	3	0	7	149	4	149	50	4	41	0	2	8	0	0	417
Sub -total	5	0	328	335	9	335	102	7	43	0	2	13	1	1	1181
Grand - Total	7	2	545	579	25	579	178	11	65	0	3	33	1	1	2029

Appendix 2: Total activites recorded in Songor Ramsar site - 2017 - 2019

Year / turtle speceis	Species / activities														
2017/2018	live	stranding	dead	nest crawls	non nest crawls	nest spots	nest predation	USPA	poached	by-catch	Rescued	hacthed nest	disorient	reorient	Totals
Olive ridley turtles	1	0	167	84	11	84	59	3	2	0	0	7	0	0	418
Green turtles	0	0	42	4	1	4	0	0	0	0	0	0	0	0	51
Leatherback turtles	0	0	3	73	3	73	3	1	0	0	0	7	0	0	163

Hawksbill turtle	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Sub- total	1	0	213	161	15	161	62	4	2	0	0	14	0	0	633
2018/2019															
Olive ridley turtles	0	0	263	34	4	34	48	2	2	0	0	5	0	0	392
Green turtles	0	0	56	0	1	0	0	0	0	0	0	0	0	0	57
Leatherback turtles	2	0	2	152	0	152	4	1	0	0	0	0	1	1	315
Hawksbill turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub- total	2	0	321	186	5	186	52	3	2	0	0	5	1	1	764
Grand total	3	0	534	347	20	347	114	7	4	0	0	19	1	1	1397

Appendix 3: Total activites recorded in Keta Lagoon Complex Ramsar site - 2017 - 2019

Year / turtle speceis	Species / activities														
2017/2018	live	stranding	dead	nest crawls	non nest crawls	nest spots	nest predation	USPA	poached	by-catch	Rescued	hacthed nest	disorient	reorient	Totals
Olive ridley turtles	0	1	2	17	1	17	12	0	3	0	0	2	0	0	55
Green turtles	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Leatherback turtles	1	1	1	66	0	66	2	0	17	0	1	4	0	0	159
Sub- total	1	2	4	83	1	83	14	0	20	0	1	6	0	0	215
2018/2019															

Olive ridley turtles	0	0	5	32	4	32	47	2	6	0	0	7	0	0	135
Green turtles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leatherback turtles	3	0	2	117	0	117	3	2	35	0	2	1	0	0	282
Sub- total	3	0	7	149	4	149	50	4	41	0	2	8	0	0	417
Grand totals	4	2	11	232	5	232	64	4	61	0	3	14	0	0	632

Appendix 4: Songor Ramsar site, erosion data, sampling site 1 (Ad SS1) 2017-2018

Month / Sampling Area	Estuary	Azizanya	Dist Assembly	Anyakpor	Elavanyo	Total	Monthly mean
July	0	21.90	0	0	0	21.9	4.38
August	0	0	0	0	0	0	0
September	0	14.50	1.40	0	0	15.9	3.18
October	0	10.0	0	0	27.8	37.8	7.56
November	0	0	3.90	20.2	0	24.1	4.82
December	0	67.60	24.0	19.6	8.40	119.6	23.92
January	2.90	8.40	0	31.1	0	42.4	8.48
February	31.90	0	0	4.70	28.7	65.3	13.06
March	0	12.0	0	0	0	12.0	2.40
Totals	34.80	134.4	29.30	75.6	64.9	339	
Mean/Sampling Area	3.86	14.93	3.25	8.40	7.21	37.66	

Appendix 5: Songor Ramsar site, accretion data, sampling site 1 (Ad SS1) 2017-2018

Month / Sampling Area	Estuary	Azizanya	Dist Assembly	Anyakpor	Elavanyo	Total	Monthly mean
July	2.80	0	1.60	2.40	10.2	17	3.4
August	2.40	16.20	3.10	17.5	3.40	42.6	8.52
September	2.60	0		26.1	3.90	32.6	6.52
October	4.40	0	1.20	50.5	0	56.1	11.2
November	58.0	90.40	0	0	43.30	191.7	38.34
December	16.4	0	0	0	0	16.4	3.28
January	0	0	2.70	0	1.0	3.7	0.74
February	0	13.20	1.20	0	0.0	14.4	2.88
March	13.20	0	16.8	4.40	19.20	53.6	10.72
Totals	99.80	119.80	26.6	100.9	81.0	428.1	
Mean/Sampling Area	11.08	13.31	2.95	11.21	9.0	47.56	

Appendix 6: Songor Ramsar site, data on dune height, sampling site 1 (Ad SS1) 2017-2018

Month / Sampling Area	Estuary	Azizanya	Dist Assembly	Anyakpor	Elavanyo	Totals	Monthly mean
July	0.20	0.40	1.20	0.45	0.35	2.60	0.52
August	0.25	0.40	0.60	1.80	0.30	3.35	0.67
September	0.20	0.10	0.60	0.60	0.20	1.70	0.34
October	0.20	0.35	0.60	0.40	0.35	1.90	0.38
November	0.15	0.10	0.90	0.40	0.10	1.65	0.33
December	0.25	0.10	0.55	0.55	0.30	1.75	0.35

January	0.35	0.15	0.75	0.40	0.25	1.90	0.38
February	0.65	0.50	0.65	0.30	0.30	2.40	0.48
March	0.50	0.45	0.60	0.45	0.10	2.10	0.42
Totals	2.75	2.55	6.45	5.35	2.25	19.35	
Mean/Sampling Area	0.30	0.28	1.29	0.59	0.25	2.15	

Appendix 7: Songor Ramsar site, erosion data, sampling site 2 (Ad SS1) 2017-2018

Month / Sampling Area	Totope	Kablevu	Wokumagbe	Total	Monthly mean
July	0	8.70	0	8.70	2.90
August	0	0	3.60	3.60	1.20
September	0	0	1.60	1.60	0.53
October	0	44.40	1.30	45.7	15.23
November	43.40	0	0	43.4	14.46
December	1.80	16.40	6.30	24.5	8.16
January	1.10	0	0	1.10	0.36
February	0.50	28.30	0	28.8	9.60
March	0	0	15.9	15.90	5.30
Totals	46.80	97.80	28.70	173.30	
Mean/Sampling Area	5.20	10.86	3.18	19.25	

Appendix 8: Songor Ramsar site, accretion data, sampling site 2 (Ad SS1) 2017-2018

Month / Sampling Area	Totope	Kablevu	Wokumagbe	Total	Monthly mean
July	1.60	0	5.30	6.90	2.30
August	9.40	22.8	0	32.20	10.73
September	17.60	7.40	0	25.0	8.33
October	26.30	0	0	26.30	8.76
November	0	24.10	5.10	29.20	9.73
December	0	0	0	0	0
January	0	18.20	10.30	28.50	9.50
February	0	0	6.0	6.0	2.0
March	2.40	7.20	0	9.60	3.20
Totals	57.30	79.70	26.70	163.70	
Mean/Sampling Area	6.36	8.85	2.97	18.18	

Appendix 9: Songor Ramsar site, data on dune height, sampling site 2 (Ad SS1) 2017-2018

Month / Sampling Area	Totope	Kablevu	Wokumagbe	Totals	Monthly mean
July	0.25	0.60	0.45	1.30	0.43
August	0.20	0.40	0.40	1.0	0.30
September	0.10	0.10	0.40	0.60	0.20
October	0.30	0.45	0.45	1.20	0.40
November	0.15	0.10	0.40	0.65	0.21
December	0.25	0.30	0.30	0.85	0.28
January	0.10	0.10	0.30	0.50	0.16
February	0.10	0.15	0.15	0.40	0.13
March	0.20	0.20	0.50	0.90	0.30
Totals	1.65	2.40	3.35	7.40	

Mean/Sampling Area	1.65	0.26	0.37	0.82

Appendix 10: Songor Ramsar site, erosion data, sampling site 1 (Ad SS1) 2018-2019

Month / Sampling Area	Estuary	Azizanya	Dist Assembly	Anyakpor	Elavanyo	Total	Monthly mean
April	9.6	12	18	6	14.4	60	12
May	2.4	0	1.2	0	18	21.6	4.32
June	0	0	1.2	0	0	1.2	0.24
July	10.5	21	0.6	12.4	0	44.5	8.9
August	20.8	0	0	0	0	20.8	4.16
September	0	18	7.6	7.4	6	39	7.8
October	0	0	0	13	0	13	2.6
November	52	0	0	0	7	59	11.8
December	0	2	0	0	8	10	2
January	0	0	0	0	0	0	0
February	0	152	0	0	50	202	40.4
March	2	0	0	1	4	7	1.4
Totals	97.3	205	28.6	39.8	107.4	478.1	
Mean/Sampling Area	8.11	17.08	2.38	3.25	8.92	39.84	

Appendix 11: Songor Ramsar site, accretion data, sampling site 1 (Ad SS1) 2018-2019

Month / Sampling Area	Estuary	Azizanya	Dist Assembly	Anyakpor	Elavanyo	Total	Monthly mean
April	0	0	0	0	0		0
May	0	0	0	0.6	0	0.6	0.12
June	4.8	7.2	0	0	1.2	13.2	2.6
July	0	0	0	1	3	4	0.8
August	0	15	0.6	0	3	18.6	3.72
September	36.8	0	0	0	0	36.8	7.36
October	49	4	1	0	6	60	12
November	0	1	1	18	0	20	4
December	81	1	0	1	0	83	16.6
January	31	169	13	2	76	291	58.2
February	0	0	0	10	0	10	2
March	0	2	0	0	0	2	0.4
Totals	202.6	199.2	15.6	32.6	89.2	539.2	
Mean/Sampling Area	16.88	16.6	1.3	2.72	7.43	44.93	

Appendix 12: Songor Ramsar site, data on dune height, sampling site 1 (Ad SS1) 2018-2019

Month / Sampling Area	Estuary	Azizanya	Dist Assembly	Anyakpor	Elavanyo	Totals	Monthly mean
April	0.10	0.55	0.25	0.15	0.10	1.15	0.23
May	0.45	0.40	0.55	0.35	0.20	1.95	0.39
June	1.20	0.45	0.60	0.20	0.10	2.55	0.51
July	1.10	2.20	1.50	1.30	0.40	6.50	1.30
August	0.90	1.30	1.10	0.90	0.30	4.50	0.90
September	0.90	0.70	0.90	0.45	0.35	3.30	0.66
October	0.80	0.78	1.35	0.90	0.30	4.13	0.83
November	0.65	0.5	0.65	0.55	0.45	2.80	0.56
December	0.10	0.15	0.60	0.70	0.10	1.65	0.33
January	0.50	0.25	0.25	1.20	0.35	2.55	0.51
February	0.0	0.45	0.55	0.55	0.25	1.8	0.36
March	0.45	0.65	0.45	0.65	0.40	2.60	0.52
Totals	7.15	8.38	8.75	7.90	3.30	35.48	
Mean/Sampling Area	0.60	0.70	0.73	0.66	0.28	2.97	

Appendix 13: Songor Ramsar site, erosion data, sampling site 2 (Ad SS1) 2018-2019

Month / Sampling Area	Totope	Kablevu	Wokumagbe	Total	Monthly mean
April	1.2	19.2	17.8	38.2	12.73
May	0	51.6	0	51.6	17.2
June	10.7	0	12	22.7	7.56
July	7.2	19.8	3.4	30.4	10.3
August	0	0	0.2	0.2	0.06
September	14.8	14.7	5.8	35.3	11.76
October	0	14	0	14	4.6

November	5	0	0	5	1.66
December	5		6	11	3.66
January	0	0	0	0	0
February	166	44	42	252	84
March	8	0	2	10	3.33
Totals	217.9	163.3	89.2	470.4	
Mean/Sampling Area	18.16	13.61	7.43	39.2	

Appendix 14: Songor Ramsar site, accretion data, sampling site 2 (Ad SS1) 2018-2019

Month / Sampling Area	Totope	Kablevu	Wokumagbe	Total	Monthly mean
April	0	0	0	0	0
May	5.9	0	18	23.9	7.96
June	0	5.9	0	5.9	1.96
July	0	0	0	0	0
August	10.8	0	0	10.8	3.6
September	0	10.8	0	10.8	3.6
October	15	0	5	20	6.66
November	0	7	9	16	5.33
December	0	29	0	29	9.66
January	188	15	40	243	81
February	219.7	67.7	72	359.4	119.8
March	0	6	0	6	2
Totals	439.4	141.4	144	724.8	
Mean/Sampling Area	36.62	11.78	12	60.4	

Appendix 15: Songor Ramsar site, data on dune height, sampling site 2 (Ad SS1) 2018-2019

Month / Sampling Area	Totope	Kablevu	Wokumagbe	Totals	Monthly mean
April	0.10	0.10	0.35	0.55	0.18
May	0.15	0.15	0.55	0.85	0.28
June	0.20	0.20	0.55	0.95	0.31
July	0.40	0.40	0.50	1.30	0.43
August	0.60	0.60	0.45	1.65	0.55
September	0.10	0.10	0.80	1.00	0.33
October	0.20	0.20	0.60	1.00	0.33
November	0.30	0.15	0.50	0.95	0.32
December	0.30	0.25	0.45	1.00	0.33
January	0.15	0.35	0.55	1.05	0.35
February	0.50	0.15	0.40	1.05	0.35
March	0.30	0.35	0.55	1.20	0.40
Totals	3.30	3.00	6.25	12.55	
Mean/Sampling Area	0.28	0.25	0.52	1.05	

Appendix 16: Keta Lagoon Complex Ramsar site, erosion data, sampling site 1 (KA SS1) 2017-2018

month / sampling site	Estuary 1	Estuary 2	Fuveme	Waakyekope	Dzita	Totals	Monthly mean
July	3.1	2.9	1.1	0	5.7	12.8	2.56
August	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0
October	21.3	0	34.5	37.5	0	93.3	18.66
November	4.1	0	0	0	1.9	6	1.2
December	3.1	0	0	21	0	24.1	4.82

January	2	0	62.9	0	0.1	65	13
February	7.1	91.7	1.9	1.9	0	102.6	20.52
March	0	0	7.1	12.6	7.2	26.9	5.38
Totals	40.7	94.6	107.5	73	14.9	330.7	
Mean /sampling area	4.52	10.51	11.94	8.11	1.65	36.74	

Appendix 17: Keta Lagoon Complex Ramsar site, accretion data, sampling site 1 (KA SS1) 2017-2018

month / sampling site	Estuary 1	Estuary 2	Fuveme	Waakyekope	Dzita	Totals	Monthly mean
July	0	0	0	10	0	10	2
August	6.1	8.2	8.1	32.5	22.9	77.8	15.56
September	4.5	10.7	30.5	20.4	1.2	67.3	13.46
October	0	19.1	0	0	1.4	20.5	4.1
November	0	5.9	61.9	0.1	0	67.9	13.58
December	0	0.6	24.1	0	5.2	29.9	5.98
January	0	26.2	0	49.7	0	75.9	15.18
February	0	0	0	2.7	12.2	14.9	2.98
March	31	79.1	0	0	0	110.1	22.02
Totals	41.6	149.8	124.6	115.4	42.9	474.3	
Mean /sampling area	4.62	16.55	13.84	12.82	4.76	52.59	

Appendix 18: Keta Lagoon Complex Ramsar site, data on dune height, sampling site 1 (KA SS1) 2017-2018

month / sampling site	Estuary 1	Estuary 2	Fuveme	Waakyekope		Totals	Monthly mean
July	0.50	0.35	0.10	0.35	1.35	2.65	0.53
August	0.10	0.30	0.50	0.40	0.60	1.90	0.38
September	0.01	0.26	0.25	0.25	0.30	1.07	0.21
October	0.20	0.60	0.30	0.40	0.40	1.90	0.38
November	0.25	0.30	0.15	0.38	0.40	1.48	0.30
December	0.30	0.60	0.45	0.45	0.20	2.00	0.4
January	0.40	0.50	0.15	0.40	0.30	1.75	0.35
February	0.70	1.50	0.80	1.20	0.25	4.45	0.89
March	0.50	0.25	0.40	0.55	0.30	2.00	0.40
Totals	2.96	4.66	3.10	4.38	4.10	19.20	
Mean /sampling area	0.33	0.52	0.34	0.49	0.46	2.13	

Appendix 19: Keta Lagoon Complex Ramsar site, erosion data, sampling site 2 (KA SS2) 2017-2018

month / sampling site	Akplortokor	Atokor	Total	Monthly mean
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	23.6	0	23.6	11.8
November	18.3	12.7	31	15.5
December	0	0	0	0
January	0	0	0	0
February	0	39.6	39.6	19.8
March	0	27.3	27.3	24.6
Totals	41.9	79.6	121.5	
Mean /sampling area	7.08	8.84	15.93	

Appendix 20: Keta Lagoon Complex Ramsar site, accretsion data, sampling site 2 (KA SS2) 2017-2018

month / sampling site	Akplortokor	Atokor	Totals	Monthly mean
July	7	6.9	13.9	6.95
August	13.4	21.6	35	17.5
September	11	3.4	14.4	7.2
October	0	7	7	3.5
November	0	0	0	0
December	12.3	18.7	31	15.5
January	12	60.9	72.9	21.45
February	10.8	0	10.8	5.4
March	0	0	0	0
Totals	66.5	118.5	185	
Mean /sampling area	7.38	13.16	20.55	

Appendix 21: Keta Lagoon Complex Ramsar site, data on dune height, sampling site 2 (KA SS2) 2017-2018

month / sampling site	Akplortokor	Atokor	Total	Monthly mean
July	0.35	1.20	1.55	0.77
August	0.30	0.40	0.70	0.35
September	0.10	0.10	0.20	0.10
October	0.35	0.20	0.55	0.27
November	0.40	0.40	0.80	0.40
December	0.35	0.20	0.55	0.27
January	0.30	0.35	0.65	0.33
February	0.45	0.05	0.50	0.25
March	0.35	0.25	0.60	0.30
Totals	2.95	3.15	6.10	
Mean /sampling area	0.49	0.35	0.67	

Appendix 22: Keta Lagoon Complex Ramsar site, erosion data, sampling site 3 (KA SS3) 2017-2018

month / sampling site	Kportorgbui	Light house	Total	Monthly mean
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	9	16.2	25.2	12.6
December	7.9	0	7.9	3.95
January	21.7	3.8	25.5	12.75
February	0	0	0	0
March	0	86.9	86.9	43.45
Totals	38.6	106.9	145.5	
Mean /sampling area	4.28	11.87	16.16	

Appendix 23: Keta Lagoon Complex Ramsar site, accretion data, sampling site 3 (KA SS3) 2017-2018

month / sampling site	Kportorgbui	Light house	Total	Monthly mean
July	2.1	12.5	14.6	7.3
August	19.9	7.4	27.3	13.65
September	13	20.1	33.1	16.55
October	25.3	36.6	61.9	30.95
November	0	0	0	0
December	0	19	19	9.5
January	0	0	0	0
February	0.1	9.8	9.9	4.95
March	52.08	0	52.08	26.04
Totals	112.48	105.4	217.88	
Mean /sampling area	12.49	11.71	24.21	

Appendix 24: Keta Lagoon Complex Ramsar site, data on dune height, sampling site 3 (KA SS3) 2017-2018

month / sampling site	Kportorgbui	Light house	Total	Monthly mean
July	0.10	0.80	0.90	0.45
August	0.40	0.45	0.85	0.43
September	0.10	0.1	0.20	0.10
October	0.40	0.3	0.70	0.35
November	0.30	0.4	0.70	0.35
December	0.50	0.25	0.75	0.38
January	0.60	0.3	0.90	0.45
February	0.45	0.25	0.70	0.35
March	0.50	0.5	0.10	0.05
Totals	3.35	3.35	6.70	
Mean /sampling area	0.37	0.37	0.74	

Appendix 25: Keta Lagoon Complex Ramsar site, erosion data, sampling site 4 (KA SS4) 2017-2018

month / sampling site	Aborigines hotel	Imancipation resort	Total	Monthly mean
July	0	0	0	0
August	0	0	0.0	0
September	0	10.10	10.1	5.05
October	0	17.80	17.8	8.90
November	12.90	11.30	24.2	12.10
December	7.90	2.90	10.8	5.40
January	0.80	0	0.80	0.40
February	22.30	0	22.30	11.15
March	0	6.0	6.00	3.0
Totals	43.90	48.1	92.00	
Mean /sampling area	4.87	5.3	10.22	

Appendix 26: Keta Lagoon Complex Ramsar site, accretion data, sampling site 4 (KA SS4) 2017-2018

month / sampling site	Aborigines hotel	Imancipation resort	Total	Monthly mean
July	9.9	13.5	23.4	11.7
August	4.3	14.7	19	9.5
September	16.8	0	16.8	8.4
October	9.1	0	9.1	4.55
November	0	0	0	0
December	0	0	0	0
January	0	37.7	37.7	18.85
February	0	4	4	2
March	11.8	0	11.8	5.9
Totals	51.9	69.9	121.8	
Mean /sampling area	25.95	7.76	13.53	

Appendix 27: Keta Lagoon Complex Ramsar site, dune height data, sampling site 4 (KA SS4) 2017-2018

month / sampling site	Aborigines hotel	Imancipation resort	Total	Monthly mean
July	0.2	0.1	0.3	0.15
August	0.4	0.6	0.1	0.05
September	0.19	0.25	0.44	0.22
October	0.35	0.35	0.7	0.35
November	0.2	0.55	0.75	0.38
December	0.45	0.3	0.75	0.38
January	0.3	0.3	0.6	0.3
February	0.55	0.1	0.65	0.33
March	0.15	0.3	0.5	0.25
Totals	2.79	2.85	5.64	
Mean /sampling area	0.31	0.32	0.63	

Appendix 28: Keta Lagoon Complex Ramsar site, erosion data, sampling site 1 (KA SS1) 2018-2019

month / sampling site	Estuary 1	Estuary 2	Fuveme	Waakyekope	Dzita	Total	Monthly mean
April	13.2	0	14.5	12	3.6	43.3	8.66
May	0	0	18	0	1.2	19.2	3.84
June	0	0	0	2.4	0	2.4	0.48
July	2	0	4.80	0	2.40	9	1.8
August	7.6	7.2	0	2.4	4.8	22	4.4
September	0	0	7.4	36.6	5.6	49.6	9.92
October	0	0	0	0	1	1	0.2
November	0	0	16	0	1	17	3.4
December	0	0	0	0	0	0	0
January	0	0	6	1	1	8	1.6
February	0	0	15.5	8	1	24.5	4.9
March	1.1	3.2	3.6	0	0.3	8.2	1.64
Totals	23.9	10.4	85.8	62.4	21.9	204.4	
Mean / sampling area	1.99	0.87	7.15	5.2	1.83	17.03	

Appendix 29: Keta Lagoon Complex Ramsar site, accretion data, sampling site 1 (KA SS1) 2018-2019

month / sampling site	Estuary 1	Estuary 2	Fuveme	Waakyekope	Dzita	Total	Monthly mean
April	0	4.8	0	0	0	4.8	4.7
May	0	0	0	6	0	6	1.2
June	0	0	10.8	0	4.8	15.6	3.12
July	0	1.20	0	13.20	0	14.4	2.88
August	0	0	6	0	0	6	1.2
September	0	0	0	0	0	0	0
October	0	0	4	27	0	31	6.2
November	0	0	0	0	0	0	0
December	0	18	6	6	5	35	7
January	0	0	0	0	0	0	0
February	157.6	1.4	0	0	0	159	31.8
March	0	0	0	14.8	0	14.8	2.96
Totals	157.6	25.4	26.8	67	9.8	286.6	
Mean / sampling area	13.13	2.17	2.23	5.58	0.82	23.88	

Appendix 30: Keta Lagoon Complex Ramsar site, data on dune height, sampling site 1 (KA SS1) 2018-2019

month / sampling site	Estuary 1	Estuary 2	Fuveme	Waakyekope	Dzita	Totals	Monthly mean
April	0.15	0.35	0.45	0.25	1.60	2.8	0.56
May	0	0	0.80	0.45	0.25	2	0.4
June	0	0	0.55	0.35	0.45	1	0.2
July	0.10	0.70	0.60	0	0.80	2.20	0.44

August	0.10	0.90	0.30	0.30	0.45	2.05	0.45
September	0	0	0.60	0.70	0.55	2	0.4
October	0	0	0.30	0.20	0.20	1	0.2
November	0	0	0.10	0.15	0.10	0	0
December	0	0	0.90	0.50	0.35	2	0.4
January	0	0	0.65	0.45	0.45	2	0.4
February	0.5	0.45	0.55	0.10	0.65	2.3	0.46
March	0.1	0.45	0.55	0.65	0.75	2.5	0.5
Totals	0.9	2.85	6.35	4.1	6.60	21	
Mean / sampling area	0.08	0.24	0.53	0.34	0.55	1.75	

Appendix 31: Keta Lagoon Complex Ramsar site, erosion data, sampling site 2 (KA SS2) 2018-2019

month / sampling site	Akplortokor	Atokor	Total	Monthly mean
April	3.6	2.4	6	3
May	1.2	6	7.2	3.6
June	0	1.2	1.2	0.6
July	3.6	7.2	10.80	5
August	2.4	0	2.4	1.2
September	12	12.4	24.4	12.2
October	0	0	0	0
November	1	0	1	0.5
December	0	0	0	0
January	16	0	16	8
February	0	16.5	16.5	8.25
March	18	0	18	9
Totals	57.8	45.7	103.5	
Mean / sampling area	4.82	3.81	8.63	

Appendix 32: Keta Lagoon Complex Ramsar site, accretion data, sampling site 2 (KA SS2) 2018-2019

month / sampling site	Akplortokor	Atokor	Total	Monthly mean
April	0	0	0	0
May	0	0	0	0
June	1.2	0	1.2	0.6
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	1	0	1	0.5
November	1	0	1	0.5
December	8	6	14	7
January	0	28.5	28.5	14.25
February	9.5	0	9.5	4.75
March	0	39.7	39.7	19.85
Totals	20.7	74.2	94.9	
Mean / sampling area	1.73	6.18	7.91	

Appendix 33: Keta Lagoon Complex Ramsar site, data on dune heiight, sampling site 2 (KA SS2) 2018-2019

month / sampling site	Akplortokor	Atokor	Totals	Monthly mean
April	0.90	0.50	1.40	0.7
May	2.60	0.70	3.30	1.65
June	1.80	1.25	3.05	1.53
July	1.10	1.15	2.25	1.0
August	0.90	1.20	2.10	1.05
September	0.80	0.80	1.60	0.80
October	0.50	0.00	0.50	0.25
November	0.10	0.50	0.6	0.3
December	0.65	0.35	1.0	0.5
January	0.55	0.25	0.8	0.4
February	2.10	0.60	2.7	1.4
March	0.45	0.65	1.1	0.6
Totals	12.45	7.95	20.40	
Mean / sampling area	1.04	0.66	1.7	

Appendix 34: Keta Lagoon Complex Ramsar site, erosion data, sampling site 3 (KA SS3) 2018-2019

Month / sampling site	Kportorgbui	Light house	Total	Monthly mean
April	26.9	8.4	35.3	17.65
May	0	0	0	0
June		10.8	10.8	5.4
July	0	6	6.0	3
August	0	0	0	0

September	no access	0	0	0
October	18.6	0	18.6	9.3
November	0	0	0	0
December	0	13.45	13.45	6.72
January	0	0	0	0
February	173.0	9.5	182.5	91.25
March	0	0	0	0
Totals	218.5	48.15	266.65	
Mean / sampling area	18.21	4.01	22.22	

Appendix 35: Keta Lagoon Complex Ramsar site, accretion data, sampling site 3 (KA SS3) 2018-2019

Average (month)	Kportorgbui	Light house	Total	Monthly mean
April	0.0	0.0	0	0
May	1.2	6.0	7.2	3.6
June	2.4	0.0	2.4	1.2
July	1.2	0.0	1.2	0.6
August	3.6	24.0	27.6	13.8
September	0.0	31.45	31.45	15.72
October	0.0	11.59	11.59	5.8
November	5.0	9.84	14.84	7.42
December	1.0	0.0	1	0.5
January	184.0	3.37	187.37	93.69
February	0.0	0.0	0	0
March	78.0	36.0	114	57
Totals	276.4	122.25	398.65	
Mean / sampling area	23.03	10.19	33.22	

Appendix 36: Keta Lagoon Complex Ramsar site, data on dune heiight, sampling site 3 (KA SS3) 2018-2019

Month/ samplng site	Kportorgbui	Light house	Totals	Monthly mean
April	0.50	0.15	0.65	0.33
May	0.15	0.50	0.65	0.33
June	0.50	0.50	1.00	0.50
July	0.30	0.30	0.60	0.30
August	0.25	0.50	0.75	0.38
September	0.00	0.45	0.45	0.23
October	0.10	0.50	0.60	0.30
November	0.15	0.35	0.50	0.25
December	0.35	0.65	1.00	0.50
January	0.45	0.55	1.00	0.50
February	0.35	0.55	0.90	0.45
March	0.65	0.20	0.85	0.45
Totals	3.75	5.20	8.95	
Mean / sampling area	0.31	0.43	0.75	

Appendix 37: Keta Lagoon Complex Ramsar site, erosion data, sampling site 4 (KA SS4) 2018-2019

month / sampling site	Aborigines hotel	Imancipation resort	Total	Monthly mean
April	6	1.2	7.2	3.6
May	86.4	3.6	90	45
June	0	0	0	0
July	0	0	0	0
August	0	16.9	16.9	8.45
September	24.4	16	40.4	20.2
October	0	0	0	0
November	12.68	0	12.68	6.34
December	5.31	0	5.31	2.66
January	0	1.58	1.58	0.79
February	13	4	17	8.5
March	8	0	8	4
Totals	155.79	43.28	199.07	
Mean / sampling area	12.98	3.61	16.59	

Appendix 38: Keta Lagoon Complex Ramsar site, accretion data, sampling site 4 (KA SS4) 2018-2019

month / sampling site	Aborigines hotel	Imancipation resort	Total	Monthly mean
April	0	0	0	0
May	0	0	0	0
June	20.4	3.7	24.1	12.05
July	13.4	6.1	19.5	9.75
August	46.8	0	46.8	23.4
September	0	0	0	0

October	25.68	19	44.68	22.3
November	0	3	3	1.5
December	0	38.58	38.58	19.29
January	16.31	0	16.31	8.16
February	0	0	0	0
March	0	31	31	15.5
Totals	122.59	101.38	223.97	
Mean / sampling area	10.22	8.45	18.66	

Appendix 39: Keta Lagoon Complex Ramsar site, data on dune heiight, sampling site 4 (KA SS4) 2018-2019

month / sampling site	Aborigines hotel	Imancipation resort	Totals	Monthly mean
April	0.25	0.15	0.40	0.20
May	0.40	0.20	0.60	0.30
June	0.10	0.50	0.60	0.30
July	0.35	0.25	0.60	0.30
August	0.30	0.55	0.85	0.43
September	0.10	0.80	0.90	0.45
October	0.10	0.20	0.30	0.15
November	0.35	0.35	0.70	0.35
December	0.70	0.10	0.80	0.40
January	0.15	0.15	0.30	0.15
February	0.15	0.20	0.35	0.18
March	0.35	0.45	0.80	0.40
Totals	3.30	3.90	7.20	
Mean / sampling area	0.28	0.33	0.60	

Appendix 40: Songor Ramsar site - Sampling duration (2017 – 2019)

2017/2018

month	start time	end time	duration
April	7.00am	8.30	1.30
May	9.00 pm	11.10	2.10
June	4.10am	6.05	2.05
July	4.20am	6.05	2.15
August	4:35am	6.35	2.00
September	4:25am	6.25	2.00
October	4.30am	6.05	2.25
November	4.24am	6.35	2.11
December	4.15am	6.35	2.20
January	4.21am	6.50	2.29
February	4.18am	6.18	2.00
March	4.18am	6.18	2.00
			25.42 hrs

2018/2019

month	start time	end time	duration
April	5.18am	6.58	1.40
May	4.45am	6.55	2.10
June	4.40am	6.53	2.13
July	4.42am	6.19	1.23
August	4.45am	6.55	2.10
September	4.45am	6.55	2.10
October	5.22am	7.48	2.26
November	4.38am	6.39	2.01
December	5.15am	7.25	2.10
January	4.15am	6.35	2.20
February	4.10am	6.35	2.25
March	4.40am	7.45	2.05
			25. 05 hrs

Appendix 41: Keta Lagoon Complex Ramsar Site - Sampling duration (2017 – 2019)

2017/2018

month	start time	end time	duration	
April	7.19 am	9.20	2.01	
May	8.26pm	10.35	2.09	
June	4.34am	7.38	2.04	
July	4.37am	7.48	2.11	
August	4.45am	7.49	2.04	
September	4.30am	7.54	2.24	
October	4.10am	7.30	2.20	
November	4.21am	7.38	2.17	
December	4.45am	7.53	2.08	
January	4.46am	7.51	2.05	
February	4.52am	7.56	2.04	
March	4.48am	7.58	2.10	
			25.57	hrs

2018-2019

month	start time	end time	duration	
April	5.05am	7.20	2.15	
May	5.42am	7.48	2.06	
June	5.42am	7.50	2.08	
July	5.18am	6.50	1.32	
August	4.47am	6.48	2.01	
September	5.28am	7.39	2.11	
October	5.10am	7.23	2.13	
November	5.14am	7.34	2.20	
December	5.42am	7.50	2.08	
January	5.45am	7.55	2.10	
February	5.49am	7.51	2.02	
March	6.15am	7.20	2.05	
			25. 18	hrs

Appendix 42 : GPS Coordinates and features of the SRS sampling sites, Ad SS1 and Ad SS2

Station Label	Latitude	Longitude	Features	Locations	Latitude	Longitude
Ad 1 (Ad SS1)						
Ada Estuary	5.77296	0.66535	Ada Groyne 1	Midas camp	5.7700	0.6653
Pute	5.7831	0.5287	Ada Groyne 2	Azizanya	5.7707	0.6592
			Ada Groyne 3	Kewunor	5.7716	0.6531
			Ada Groyne 4		5.7725	0.6468
			Ada Groyne 5	Ayigbo	5.7735	0.6406
			Ada Groyne 6	Lolonyakope	5.7743	0.6343
			Ada Groyne 7	District Assembly office	5.7752	0.6281
			Ada Groyne 8	otrokpe	5.7763	0.6188
			Ada Groyne 9	Cocoloko beach	5.7766	0.6110
			Ada Groyne 10	Ocanseykope	5.7771	0.6046
			Ada Groyne 11	Ocanseykope school	5.7776	0.5982
			Ada Groyne 12	Anyarkpor	5.7781	0.5919
			Ada Groyne 13		5.7786	0.5855
			Ada Groyne 14	Sonstokpa beach	5.7795	0.5796
			Ada Groyne 15	Patukope beach	5.7799	0.5738
			Ada Groyne 16	Elavanyo	5.7802	0.5677
			Ada Groyne 17		5.7806	0.5613
			Ada Groyne 18		5.7811	0.5550
			Ada Groyne 19		5.7815	0.5483
			Ada Groyne 20	Pute	5.7821	0.5406

			Ada Groyne 21		5.7828	0.5347
			Ada Groyne 22	Pute	5.7831	0.5287
Ad 2 (Ad SS2)						
Totope	5.78265	0.53233				
Wokumagbe	5.7834	0.32848	-	-	-	-

Appendix 43: GPS Coordinates and features of the KLCRS sampling sites, KA SS1-KASS4

Station Label	Latitude	Longitude	Features	Locations	Latitude	Longitude
KA 1 (KA SS1)						
Fuveme	5.77320	0.69745				
Dzita	5.77245	0.79444				
KA 2 (KASS2)						
Apklortorkor	5.77232	0.80002	Groyne WTG 2	Whuti	5.7762	0.8385
Atorkor	5.77660	0.82566	Groyne WTG 1	Whuti	5.7760	0.8360
			Groyne SGL	Srogboe	5.7762	0.8343
			Groyne SG 4	Srogboe	5.7755	0.8343
			Groyne SG 3	Srogboe	5.7755	0.8327
			Groyne SG 2	Srogboe	5.7753	0.8310
			Groyne SG 1	Srogboe	5.7751	0.8291
			Groyne DG 7	Srogboe	5.7749	0.8273

			Darkorzdi DG 6	Darkordzi	5.7746	0.8255
			Darkordzi DG 4	Darkordzi	5.7742	0.8227
			Darkordzi DG 5	Darkordzi	5.7745	0.8241
			Darkordzi DG 3	Darkordzi	5.7741	0.8212
			Darkordzi DG 2	Darkordzi	5.7740	0.8197
			Darkordzi DG 1	Darkordzi	5.7737	0.8182
			Horizontal groyne		5.7735	0.8163
			Horizonal groyne		5.7735	0.8163
			Horinz groyne, protect road	Apklortorkor	5.7722	0.7923
			Beach	Apklortorkor	5.7718	0.7922
KA 3 (KASS3)						
Whuti	5.78688	0.85648				
Anloga	5.79905	0.91235				
KA 4 (KASS4)						
Woe	5.83977	0.96541	Fort Prinzenstein	Keta beach	5.9217	0.9940
Vodza	5.9328	0.9986	groyne 1	Keta	5.9273	0.9956
			Horizontal groyne	Keta Royal Beach	5.9190	0.9925
			Horizontal groyne	Keta Royal Beach	5.9190	0.9924

Groyne	Emancipation BR	5.9247	0.9946
Horizonal groyne - end		5.9255	0.9937

Appendix 45 : Features adopted to identify turtle species within the sampling areas.

Family	Dermochelydae	Lepidochelys	Cheloniidae	Eretmochelys
Species	(Dermochelys coriacea) – Leatherback	(Lepidochelys olivacea) Olive ridley	(Chelonia mydas) Green turtle	(Eretmochely imbricate) Hawksbill
Scutes	-	2 pairs of prefrontal scutes	4 pairs of coastal scutes	4 pairs of costal scutes
Scales	small scales present only in hatchlings		present on head and flippers	Head narrow, with two pairs of prefrontal scales
Carapace	carapace with 5 dorsal longitudinal ridges carapace with 5 dorsal longitudinal ridges.	Nearly circular shape, slightly hearty-shaped	Radiating streaks	elliptical, covered by imbricate scutes except in very old individual
Carapace colour	Black in color with white, pink, and grayish spots	gray to olive green	olive brown to almost black	Tan, brown carapace and black with random streaks
Plastron / colour	white with dark blotches	white/yellow, usually with 4 pairs of pored inframarginal scutes	White to yellow	Cream with dark blotches
Flippers	without visible claws	Front flippers medium-sized, usually with one or two (sometimes three) claws on the anterior border.	with one or two developed claws.	usually with two evident claws
chaonae	open in two separate apertures on anterior half of palate		open in a single aperture on the rear half of palate	

Appendix 46: Data collection form 1 – Species and environmental

No.	comments	Position (N)	Position (E)	location	dune ht (cm)	species	speceis status	nest status	N / DFB (m)	nest depth(cm)	Substrate depth (cm)	sand texture

Appendix 47: Data collection form 2- species and environmental

month	live	stranding	dead	nest crawls	non nest crawls	nest spots	nest predation	USPA	poaching	method	by-catch	Released	hatchlings	disorient	reorient	tumor	epizoite	tag

Appendix 48: Data collection form 3 – beach data

2018-2019	2018															
months	Apr		May		June		July		Aug		Sept		Oct		Nov	
Sampling points / sampling coordinates	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Estuary 1																
Estuary 2																

Appendix 49: Summary ANOVA for Dead Turtles for 2017-2018 – Songor Ramsar Site .

Groups	Count	Sum	Average	Variance
Olive Ridley	3	167	55.6666667	1364.33333
Green Turtle	3	42	14	108
Leatherback	3	3	1	3
Hawksbill	3	1	0.33333333	0.33333333

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	6106.916667	3	2035.63889	5.51788269	0.02383133	4.06618055
Within Groups	2951.333333	8	368.916667			
Total	9058.25	11				

Appendix 50: Summary correlation for mean dune height and nesting activities, Songor Ramsar Site

	Mean Dune ht	Nest Crawls	Non Nest Crawls	Nest Spots
Mean Dune ht	1			
Nest Crawls	-0.312461984	1		
Non Nest Crawls	-0.206972405	-0.150242585	1	
Nest Spots	-0.312461984	1	-0.150242585	1

Appendix 51: Summary correlation for mean dune height and nesting activities, Songor Ramsar Site

	Mean Erosion	Nest Crawls	Non Nest Crawls	Nest Spots
Mean Erosion	1			
Nest Crawls	-0.117220303	1		
Non Nest Crawls	0.411088665	-0.150242585	1	
Nest Spots	-0.117220303	1	-0.150242585	1

Appendix 52: Summary correlation for mean dune height and nesting activities, Songor Ramsar Site

	Mean Accretion	Nest Crawls	Non Nest Crawls	Nest Spots
Mean Accretion	1			
Nest Crawls	0.372032593	1		
Non Nest Crawls	-0.038576375	-0.150242585	1	
Nest Spots	0.372032593	1	-0.150242585	1