DISTRIBUTION AND ECOLOGY OF NESTING SEA TURTLES IN GHANA.

BY

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DEDICATION

This work is affectionately dedicated to the entire

AMITEYE FAMILY

That they may live to appreciate the power of knowledge and pursue it to its highest pinnacle.

DECLARATION

I hereby declare that this work is a product of my own research work and that no part has ever been presented as thesis elsewhere.

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ABSTRACT

Information on the occurrence and reproductive biology of sea turtles in Ghana is very scanty, therefore there is a need for detailed scientific studies on which their conservation and protection could be based. The present study has shown that the Olive ridley, Leatherback and Green turtles are the three main species that continue to nest on the beaches along the coast of Ghana. The Olive ridley having the highest relative abundance of 91% at the intensive study area followed by the Leatherback turtle with 6% and the Green turtle 3%.

The nesting season begins in August and extends to March, sometimes early April. It peaks in October for the Olive ridley and between December and January for the Green and Leatherback turtles. The Olive ridley turtles arrive first, followed by the green and Leatherback turtles. The nesting period of the Green and Leatherback turtles overlaps that of the Olive ridley.

Sea turtles nest in a wide range of beach sediment type along the coast of Ghana. Beach sand with median grain size between 0.2-0.4 mm (medium to coarse sand) and sorting coefficient between 0.4-0.7 (well-sorted to moderately well sorted) are those preferred by nesting turtles along the coast of Ghana. Based on the above grain characteristics, the potential sea turtle nesting sites in Ghana may include beaches along PrincessTown to Busua, Senya Bereku to Accra, Prampram to Old Ningo and Anloga to Denu.

Estimated average clutch size for Olive ridley, Green and Leatherback turtles were 86, 83 and 81 respectively. However, those counted for the Olive ridley and Leatherback were 100 (SD=6.64) and 85 (SD=10) respectively. Emergence period for the Olive ridley was 52 days,

Green turtle 56 days and Leatherback 63 days. Percentage hatching success was very high among all the three nesting species with Olive ridley recording the highest with 92.40%.The percentage hatching success for the other two, Green turtle and leatherback were respectively 89.38 and 88.32.

Destruction of sea turtle eggs by dogs at the intensive study area was very high, but this problem was not widespread along the entire coast of Ghana. Percentage false crawls where found to be higher within zones closer to human habitation.

CHAPTER ONE

GENERAL INTRODUCTION AND OBJECTIVE OF STUDY

1.0 INTRODUCTION

The loss of the world's biodiversity is of a major concern to the world's nations. This concern is embodied in the Convention on Biological diversity negotiated by the United Nations at Rio de Janeiro in 1992. The Convention aims to protect the world's biological resources from further extinction, or at least slow down the rate of this decline. Nonetheless, the rate of biodiversity loss is increasing (Pearce and Moran, 1994) as a result of natural causes, climatic changes, over-exploitation and habitat destruction by man. It is for this reason that some organisms including sea turtles have been listed as either endangered or threatened species by the World Conservation Union (IUCN) (Groombridge, 1982).

According to Márquez (1990), sea turtles were common and lived with the dinosaurs in the Cretaceous era (130 million years ago) and their fossil record even extends back to about 200 million years. They form an important component of marine ecosystems (Pritchard, 1997), and reach an average age of 150 years; some reaching monstrous sizes and weigh about a ton (907 kg) (Groves and Hunt, 1980). Taxonomically, sea turtles belong to two families which are sub-divided into six genera. Presently only eight species of marine turtles exist world wide. These are:

Green turtle	*Chelonia mydas* (Linnaeus, 1758)
Black turtle	*Chelonia agassizi* (Bocourt, 1868)
Flatback	*Natator depressus* (Garman, 1880)

Loggerhead *Caretta caretta* (Linnaeus, 1758)

Hawksbill *Eretmochelys imbricata* (Linnaeus, 1766)

Olive ridley *Lepidochelys olivacea* (Eschscholtz, 1829)

Kemp's ridley *Lepidochelys kempii* (Garman, 1880)

Leatherback *Dermochelys coriacea* (Vandelli, 1761)

However, some authorities classify the Black and Green turtles as the same species. This is because the systematic status and nomenclature of the Black turtle remains uncertain. Recent genetic evidence is said to support an Atlantic-Mediterranean versus Indian-Pacific grouping, while morphological and behavioural data suggest an east Pacific species or subspecies (Eckert *et al*., 1999). Various arguments have been presented in favour and against the designation of the Black turtle as a full species within the genus Chelonia (Bowen and Karl, 1996; Pritchard and Mortimer, 1999). In this study, the full species concept is based on the traditional criteria of the degree of morphological divergence and probable existence of reproductive isolation mechanisms (Pritchard and Mortimer, 1999). Sea turtles belong to the Kingdom Animalia, Subphylum Vertebrata and Class Reptilia. They are separated into two families namely:

a) Dermochelyidae, that contains the leatherback *Dermochelys coriacea* as the only living species.

b) Cheloniidae, with two subfamilies:

i) Chelonini, which includes the green (*Chelonia mydas)*, the flatback (*Natator depressus*) and the hawksbill (*Eretmochelys imbricata)* turtles.

ii) Carettini, which includes the loggerhead (*Caretta caretta*), the Olive or Pacific ridley (*Lepidochelys olivacea*) and Kemp's or Atlantic ridley (*L. kempi*)

(Butterworth, 1989). A review of Ghanaian species and their status is given in Chapter 2 of this thesis.

1.1 LEGAL STATUS OF SEA TURTLES

All sea turtles have been listed by IUCN as endangered or threatened except *Natator depressus*. However, the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) lists all marine turtles on its Appendix I. That means, international sale of sea turtles and their products is illegal among the 142 signatory nations as of September, 1997 (Anon, 1997, Lagueux, 1998). CITES was adopted in Washington, on March 3, 1973 and signed by Ghana on February 12, 1976. Other treaties and conventions such as the Convention on Biological Diversity; Convention on the Conservation of Migratory species of Wild Animals (Bonn Convention or CMS, adopted in Bonn on June 23, 1979); African Convention on the Conservation of Nature and Natural Resources (adopted at Algeria on Sept. 15, 1968 and signed by Ghana on October 9, 1969) also protect sea turtles. In Ghana, sea turtles are protected by the Wildlife Conservation Regulations, 1971, L. I 685 (Armah and Amlalo, 1998) which has its IUCN number as 841340 (H-971043000) (Navid, 1982).

1.2 ECONOMIC IMPORTANCE OF SEA TURTLES

Sea turtles as a natural resource are used by local communities in various ways just as other natural resources are harvested to meet dietary, medical, cultural, economical and religious human needs and wants (Lagueux, 1998; Robison and Redford, 1991; Robison, 1994; Jorgenson, 1993; Freese, 1997). Sea turtles are exploited for their eggs, meat, shell, skin and other products. All species of sea turtles suffer from the collection of eggs and hunting for meat, which is a significant source of protein in many protein- deficient coastal regions of the tropics. To many communities the meat is a delicacy. The eggs are eaten not only for its nutritional value, but also for its purported aphrodisiac qualities. Green turtles are liked for their meat and cartilage as well as their shells and bodies, which are stuffed and sold as curios for the tourist trade. The bones are used to make house ware items, decorative artwork, ornaments, jewellery, and fertiliser (Mark *et al.*, 1982 and Canin, 1989).

They also have aesthetic value. For example, Pacific ridley skin is used to fashion boots, shoes, handbags and other accessories, and oil rendered from the carcass is used for everything from skin lotion additives to boat caulking agents. Hawksbills shells are highly desired as a decorative ornament, or the scutes from their shells used to craft jewellery, combs and eyeglass frames.

Oil from sea turtle is believed to cure several ailments. Sea turtle oil is used as medicine or tonic by the Aboriginal and Torres Strait Islanders in coastal areas of northern Australia. The oil is used for protection against evil spirits in Kenya (Wamukoya *et al.*, 1996) and as medicine for sore muscles and hernia in Tanzania (Howell and Mbindo, 1996). Among the Mauritian Creole community, blood from turtle is a traditional cure for asthma in children (Mangar and Chapman, 1996). The bone of "turtle tail" is grated into tea and believed to be a powerful aphrodisiac and the meat is said to make one strong so it is eaten by members of the local football teams in Mauritius (Mangar and Chapman, 1996). However, in Ghana, when mixed with honey, the oil from sea turtle is used to treat convulsion in children among some local communities in the Volta region. In some coastal communities, sea turtles have been object of ancient ritual practices, whiles in some areas they are venerated as sacred animals (Márquez, 1990). In Ghana, the people of Old Ningo regard sea turtles as a totem and therefore revere them (Armah *et al.*, 1997). Islamic precept considers sea turtle meat unclean (Fretey and Fourmy, 1996) hence not eaten by some Moslems. In Zanzibar, some fishermen believe that Islam prohibits the consumption of turtle meat since animals that live on both land and water are considered impure (Khatib *et al.*, 1996). Muslims in Indonesia and Thailand also avoid turtle meat, but eat turtle eggs in large quantities (Hill, 1991). Sea turtle meat is used as bait for lagoon fishing. In Nicaragua, Loggerhead turtle meat is not consumed but harvested and used as shark and lobster trap bait, due to its strong flavour (Lagueux, 1998). Shells of the Hawksbill turtles are used by artisans in the Seychelles for handicrafts (combs, jewellery cases, trinkets etc.) which are sold to tourists. In some communities in the Seychelles, turtle shells are used as water containers, and when polished, the shells are used as trophies.

Exploitation of sea turtles for international trade had existed for centuries. Marine turtle fishery industry existed in Mexico until it was bought from private owners in June 1980 (Romero, 1980). The leather industries in Italy, France, Germany and the United Kingdom all formerly produced a variety of leather products made from sea turtles. Hawksbill shell was widely used in Europe for the production of expensive eyeglass frames and other items. In Nicaragua, Hawksbills are still harvested by some communities for their scutes (Lagueux, 1998). In the 1980s, Japan was ranked as the world's foremost importer of sea turtle products, with 86% emanating from Latin America / Caribbean and Asia /Pacific regions. Only 12% of the overall total was imported from the Africa / India ocean nations.

Sea turtle shells also serve as substrate for some sessile barnacles. Specimens of barnacle *Chelonibia testudinaria* were collected from the back of a green turtle (Mustaquim and Javed, 1993). Sea anemones *Adamsia*, *Metridium* and *Balanus* barnacles have been found on olive ridleys. Hawksbill turtle is the only known spongivore marine reptile (Meylan, 1988). Even, strictly spongivore vertebrates include only a small number of teleostean fishes (Márquez, 1990) hence hawksbill turtles might therefore play an important role in checking the populations of sponges.

1.3 THREATS TO SEA TURTLES

1.3.1 NATURAL ENEMIES:

Sea turtles face a lot of threats within the environment in which they find themselves. For example, turtle eggs are susceptible to terrestrial predation by birds, ghost crabs (*Ocypode* sp.), racoons, armadillos and ants. Black vultures (*Coragyps atratus*) and turkey vultures (*Cathartes aura*) prey on both eggs and hatchlings, whiles the Yellow crowned night herons (*Nyctanassa violacea*) eat sea turtle hatchlings (Troëng, 1997). Coatis *(Nasua narica*) have been observed feeding on green turtle eggs. Wild pigs and dogs also destroy the eggs. This is so high in some areas such as Gahirmatha beach (India) where only four or five hatchlings out of some 1000 eggs survive. Hatchlings also suffer from predation by bony fish and sharks (George, 1997), dolphins and octopus.

Parasitic infections have been reported in sea turtles. Two species of leeches are known to parasitize sea turtles. These are *Ozobranchus branchiatus* found on only green turtles that inhabit tropical waters, and *O. margoi* found on most species of the sea turtles (George, 1997). Some barnacles are said to damage the underlying shells and skin of turtles allowing bacterial or fungal pathogens to enter.

1.3.2 HUMAN DIMENSIONS

Human activities affecting sea turtles range from destruction of their nesting beaches through their foraging habitats to intensive harvesting at high seas, basically, touching every stage of their life cycle. Beach armouring, beach nourishment, beach cleaning and beach driving as well as sand mining greatly cause sea turtle habitat alteration and loss.

Beach armouring is the construction of hardened structures meant to protect dune property from erosion. It involves erecting vertical or inclined concrete sea defence walls, wooden walls, rock revetments and sandbag/sand tube structures (Lutcavage *et al.*, 1997). Groynes and jetties meant to control long shore sand movement also present barriers to nesting turtles.

Beach armouring is greatest where coastal development is most widespread such as the United States of America and the Mediterranean. Beach nourishment which involves mechanical dumping or pumping of sand onto eroded beaches, is very expensive, however, it is undertaken in developed countries, where the economic value of the beach makes it worthwhile. This is found especially in some parts of Europe and the United States. Some nourished beaches have high clay, silt and shell content making them too compact for nest excavation by turtles. Wave action usually causes the formation of steep escarpments that prevent sea turtles from reaching the upper beach. Properties such as sorting, moisture content, reflection and conduction of artificially nourished substrate differ from that of the natural beach. These properties go a long way to affect the architecture of the egg chamber, incubation temperature, gas exchange and water uptake for development of clutch thereby resulting in diminished egg and hatching survivorship. The process of nourishment which involves lighting, sand spreading, and pumping activities could disturb nesting females and produce disorientation and mortality in hatchlings.

Sand mining operations also have detrimental effect on sea turtle nesting. This involves the removal of large quantities of sand from beaches for production of concrete and other construction activities. This activity destroys the beaches and eliminates nesting. According to Lutcavage *et al.*, (1997), this has been recognised as a threat to sea turtle populations, primarily in the Mediterranean. A similar situation is evident at Old Ningo, in Ghana.

Beach cleaning and beach driving also pose threat to sea turtles. Heavy vehicles can crush developing eggs and pre-emergent hatchlings. The tyre ruts can trap hatchlings, allowing them to become exhausted or taken by predators. Vehicles operated at night can also disturb nesting females and crush emerging hatchlings crawling toward the sea. Beach cleaning may uncover and destroy nests. Raking may leave ruts or ridges that may disrupt hatchlings' sea finding behaviour.

Artificial lighting on nesting beaches is detrimental to sea turtles. It disrupts critical behaviours such as nest-site choice and the nocturnal behaviour of both hatchling and nesting females. Both associative and direct experimental evidence showed that artificial lighting on the beaches deters sea turtles from nesting. Hatchlings move toward artificial light source rather than the sea, and succumb to exhaustion, dehydration, and predation.

Boat collisions have also been identified as causes of death of sea turtles. Sea turtle stranding data from the U.S.A, Gulf of Mexico and Atlantic coasts, Puerto Rico and U.S Virgin Islands have shown that between 1986 and 1993, about 9% of living and dead stranded sea turtles had propeller or other boat strike injuries (Lutcavage *et al* 1997). Also, between 1991 and 1993, in Florida (USA) where coastal boating is popular, frequency of boat injuries was 18% of 2,156 strandings.

Sea turtles are known to associate with offshore oil and gas platforms and can be harmed by underwater explosives detonated to remove platforms no longer in use. These explosions can cause capillary damage, disorientation, and loss of motor control in sea turtles. Those near detonation sites may sustain fatal injuries. About 50 to 500 sea turtles are estimated to be killed each year from explosive platform removal in the Gulf of Mexico (Lutcavage *et al.,* 1997). Although, specific information is not available, it is believed that petroleum seismographic canons and military manoeuvres involving explosives also have the potential to harm sea turtles.

Direct evidence of sea turtles being seriously harmed by oil spills has been showed by instances such as the oiled loggerhead nests and jeopardised hatchlings and adult female in Tampa Bay, Florida. The Mexican Ixtoc blow-out oil reached Rancho Nuevo which is the only known major nesting beach of the Kemp's ridley, and oiled sea turtles were subsequently seen in Texas coastal waters (Fritts and McGehee, 1981). In 1983, 180 hawksbill turtles were known to have been killed off the islands of Jana and Karan, near Saudi Arabia (Lutcavage *et al.*, 1997).

The list of materials found in turtles' digestive tracts is extraordinary. Plastic bags, beads, pellets, line, rope, strapping, pieces from bottles and hard pieces of unknown origin are common items ingested by sea turtles. They also ingest latex balloons, aluminium, paper, cardboard, styrofoam, rubber, string, cigarette filters, wax, cellophane, fishhooks, charcoal and glass (Plotkin and Amos, 1990). Plastics are also the most common type of debris sea turtles become entangled in and ingest. Fishing gear, particularly, monofilament line may account for about 68% of all entanglement cases (National Research Council, 1990; O'Hara and Iudicello, 1987).

Large numbers of turtles are being lost to shrimp fishing operations (Nunoo and Evans, 1997). Incidental capture of sea turtles in shrimps trawls is reported to account for more deaths than all other sources of human activities combined (National Research Council, 1990; Lutcavage *et al.*, 1997). Sea turtles are also killed when incidentally captured in purse seine, gill nets, and various types of untended fishing gear. Lobster and crab pots as well as hook and line fishing also cause entanglement, mutilation and debilitation. Sea turtle forcibly submerged in any type of restrictive fishing gear would eventually suffer fatal consequences from prolonged anoxia or seawater infiltration of the lung. Sea turtles are also vulnerable to capture in pelagic long line, paired trawl, and gill net fisheries.

1.4 OBJECTIVE OF STUDY

This has been a source of increasing concern for both fisheries managers and the industry. Although, in Ghana, the law makes it an offence punishable by fine, imprisonment or both, to capture or kill sea turtles, several cases of poaching have been reported among many coastal fishing communities. As Ghana is currently trying to boost its tourism potential, there has been an increase in coastal development such as beach resorts for recreational activities in some cases at the expense of sea turtle nesting habitats. Information on turtle occurrence and especially reproductive biology are very scanty. There is therefore no opportune time than now to conduct detailed studies on the occurrence and reproductive biology of sea turtles in Ghana to provide scientific data on which their conservation and protection could be based.

The primary objective of this study is to:

i) determine the present distribution of sea turtles on the Ghanaian coastline,

ii) identify suitable nesting beaches along the entire coast,

iii) determine the emergence period, hatching success and duration of the nesting season for each species,

iv) estimate mean clutch size of each nesting species,

v) collect biometric data for each species, and

vi) estimate the extent of destruction of nests by predators (dogs).

CHAPTER TWO

LITERATURE REVIEW

2.0 OCCURRENCE OF SEA TURTLES

2.1 GLOBAL DISTRIBUTION

Most of the eight species of sea turtles surviving presently are unevenly distributed in all the three tropical oceans, except for three species. These three species have relatively restricted distributions (Pritchard, 1997). They are the flatback (*Natator depressus)* in Northern Australia, Kemp's ridley (*Lepidochelys kempii)* in the Gulf of Mexico and North Atlantic, and black turtle (*Chelonia agassizii)* in the Eastern Pacific.

Loggerhead (*Caretta carreta)* is found in temperate and subtropical waters world-wide (Mc Diarmid, 1978). The loggerhead has been discribed by Pritchard (1997) as having an "antitropical" distribution; and this has fragmented its overall range into well-separated enclaves in the northern and southwestern Indian Ocean, eastern Australia, Japan, south eastern United States, the Mediterranean, and Southern Brazil. This fragmentation is said to bring the loggerhead into contact with industrial and development stresses ranging from massive incidental capture by shrimpers to recreational development of nesting beaches.

In the United States nesting of loggerheads occurs on suitable beaches from North Carolina to southern Florida (McDiarmid, 1978). This species also nests in the western Caribbean, Cuba, Jamaica, the Dominican Republic and Puerto Rico. Nesting sites have been reported in Mexico (Hendrickson, 1982; Sternberg, 1981). Scattered nesting occur along the eastern coasts and offshore cays of Belize, Guatemala, Honduras, Nicaragua and Colombia, and the western coast and Islands of Venezuela (Groombridge, 1982). According to Gudynas (1980) loggerheads are common coastal species in the Atlantic areas of Rocha in Uruguay, but records of its nesting is not known.

Loggerheads occur in the waters of India and Sri Lanka (Frazier, 1982), along the Chinese coast, where they appear to nest on the Xisha Islands in the South China seas (Chu-chien, 1982). Nesting has also been reported on all the southern Islands of Japan (Limpus, 1982) as well as the Great Barrier Reef area. *C. carretta* is known to be fairly common around the Mediterranean (Di Palma, 1978) where large numbers nest along the coast of Turkey to Israel. Smaller numbers also nest on the Northwest coast of Cyprus, and Zakynthos in Greece (Groombridge, 1982). The largest known nesting population of *C. caretta* is said to occur on the Masirah Island in Oman, where 30,000 females nest annually.

Green turtle (*Chelonia mydas)* is also a circumglobal species, with most of its nesting and feeding grounds lying within the tropics (Pritchard, 1997). It occurs along the West Coast of North America (Anon, 1980; Groombridge, 1982), Mexico (Sternberg, 1981), El Salvador, Honduras, Nicaragua (Cornelius, 1982), and Costa Rica (Sternberg, 1981) where the nesting colony is large and the most important in the Caribbean (Pritchard, 1997). Other major nesting colonies occur on the Galapagos, the Barrier Reef Islands (Australia), d'Entrecasteaux Reef (New Caledonia) and Oceanic Islands such as the Ascension Island (Pritchard, 1997). They also occur in the

Uruguayan waters (Gudynas, 1980) and Aves Island, Venezuela (Groombridge, 1982).

In Australia *C. mydas* rookies occur around the area of the Great Barrier Reef of which the coral sea, southern Papua New Guinea, New Caledonia, the Torres strait and the Northern Territory serve as feeding grounds. The French Frigate shoals in the Hawaiian archipelago of the central Pacific are important breeding sites for this species.

Nesting green turtles have been observed on some beaches in Pakistan, India, Thailand and Malaysia. They occur along the coasts of Taiwan, China and Japan.
C. mydas is common in Yemen, Oman (Ross and Barwani, 1982), Bahrain, Gulf coast of Saudi Arabia and Iran. They have also been reported from the Black, Marmara and Aegean seas (Geldiay *et al.*, 1982).

Hawksbill turtle *(Eretmochelys imbricata)* is circumtropical and nests on tropical or sub-tropical beaches in the Atlantic, Indian and Pacific oceans. This species is said to be uncommon in the eastern pacific region and nest sporadically along the Central American mainland from central Mexico to Ecuador. It is known to be widespread through the Indian Ocean, with most nesting on islands such as the Suakin archipelago in the Red sea, islands off the Arabian peninsula and the Gulf, and oceanic island including the Seychelles, Lakshadweeps, Maldives right to Southern India. Occasional nesting has been reported from Thailand, eastern part of Malaysia, Indonesia, northern coast of Australia and also sparse breeding in Hawaii (Pritchard, 1979, 1982; Sternberg, 1981) and Costa Rica. *E. imbricata* occurs in the Mediterranean regions but no nesting record is available.

Kemp's ridley or Atlantic ridley *(Lepidochelys kempii)* has been classified by IUCN as critically endangered. According to Pritchard, (1997), *L. Kempii* remains the rarest sea turtle in the world and apart from few isolated cases, Racho Nuevo, in southern part of Tamaulipas, Mexico is the only known nesting site for this species.

Major known feeding ground for the adult kemp's ridley include the crab-rich shallow waters off Louisiana and the Tabasco-Campeche area of Mexico (Groombridge, 1982).

Olive ridley (*Lepidochelys olivacea)* is a circumglobal species, present in tropical regions of the Atlantic, Indian and Pacific Oceans. Record of nesting of this species is known along the Pacific coast of Central America, particularly, from North Mexico, through Guatemala, El Salvador, Honduras and Nicaragua to Panama. Synchronized aggregations ("arribadas") are said to occur in Oaxaca, Mexico and Nancite site, Costa Rica with over 200,000 nests per year. Shanker and Mohanty (1999) reports that between March 24-April 1,1999, 200,000 turtles nested on two islands which are the current nesting sites at Gahirmatha (India).

L. olivacea does not nest in the Caribbean, the only known nesting in the West Atlantic occurs in Surinam, with small numbers in Guyana. Minor to moderate nesting is known to occur on Masirah Island (Oman), Lakshadweep Islands, the Andaman Islands, Sri Lanka, Malaysia, Burma, Papua New Guinea and northern

Australia (Sternberg, 1981). Olive ridley is probably the most abundant sea turtle around the world. Though it is known principally to inhabit the northern hemisphere, with 20 °C isotherms as its distributional boundaries, non-breeding Olive ridleys outside the 20 °C isotherms have been observed as far as the Gulf of Alaska during warm weather such as the El Niño phenomena in the eastern Pacific (Márquez, 1990).

Leatherback (*Dermochelys coriacea)* is also a circumglobal species and nests on beaches of tropical seas in the Atlantic, Indian and Pacific oceans and occasionally in subtropical regions and the Mediterranean. It forages widely and regularly in temperate waters.

Dense Leatherback nesting occurred along the Pacific Coast of Mexico, specifically in Michoacan, Guerrero and Oaxaca. Also Playa Naranjo in Costa Rica is said to be an important nesting beach. However, according to Pritchard (1997), the Terengganu colony (Malaysia) has collapsed and a serious decline has been documented in both Pacific Mexico and Costa Rica; resulting from beach slaughter, egg collection and serious incidental captures by fishing gear in the open sea. The Atlantic colonies include those found in Trinidad, Surinam and French Guiana (Pritchard, 1997).

Nesting on the Atlantic coast of the Americas has been recorded from the east coast of Florida in the north, through the Caribbean region to Espirito Santo Brazil in the south (Sternberg, 1981). This species is occasionally found in the Mediterranean. Small-scale nesting occur on the island of Tobago, but much larger aggregations are known to nest on north and east coasts of Trinidad (Carr *et al.*, 1982; Sternberg, 1981).

Large aggregations of leatherbacks exist in the Union Territories of the Andaman and Nicobar Islands whereas small-scale nesting occur in Lakshadweep Islands, parts of India and in Sri Lanka (Bhaskar, 1979, Frazier, 1982). Nesting is also reported in many parts of Southeast Asia, Australia and Papua New Guinea. These include Burma, Thailand, Malaysia, Indonesia, China seas and as far north as the Yellow Sea (Chu-chien, 1982).

2.2 OCCURRENCE IN AFRICA

The History of turtles in Africa dates back to the early Jurassic period (60 million years). Along the African continent, large scale nesting of loggerhead turtle have been reported in Southern Africa, especially on Paradise Island, Mozambique and on the Tongaland coast of South Africa (Frazier, 1982; Hughes, 1982). The southern part of Madagascar around Fort Dauphin is said to be an important nesting site for the Loggerheads (Pritchard, 1979; Sternberg, 1981; Frazier, 1982; Hughes, 1982). Nesting of *C. caretta* occurs also in the Eastern Atlantic. These include Namibia (Hughes, 1982) and Morocco (Brongersma, 1982; Sternberg, 1981).

C. mydas feeds and nests throughout the Seychelles; nests on the Comoros, Tanzania and is common on the eastern coast of Somalia, Red Sea coast of Egypt (Frazier, 1982) and the Dhalak Archipelago around Ethiopia. Reports of occurrence in Namibia and South Africa but not nesting (Hughes, 1982) is available.

E. imbricata is known to occur south to Angola, Mozambique, Tanzania and Kenya. *L. olivacea* nests in good numbers in Northern Mozambique, smaller numbers in

Tanzania and rarely in South Africa. Minor nesting occur in Angola and northern part of Namibia.

Leatherback occurs around the Republic of Congo (Zaire) and Angola (Hughes, 1982, Brongersma, 1982). In the Indian Ocean nesting occurs in southern Africa, mainly along the Tongaland coast of northern Natal, South Africa (Hughes, 1982) and Mozambique (Frazier, 1982).

In West Africa loggerheads have been reported in Senegal, Guinea Bissau, Sierra Leone, Ghana and the Congo. Nesting records of *C. mydas* is available from Mauritania, Senegal, Sierra Leone (Turtle Island); Fernando Po, and Angola. However, historical records of its occurrence in Liberia, Principe and Sao Thome, the Congo and Democratic Republic of Congo (Zaire) is available (Brongersma, 1982).

E. imbricata is believed to nest on Cape Verde Island, Senegal, Mauritania and probably other areas. *L. olivacea* nests on beaches from Senegal to Angola. Minor and solitary nesting of leatherback occurs in Senegal, Liberia, Ivory Coast Togo and Ghana (Marquez, 1990).

2.3 OCCURRENCE IN GHANA

Documentation of marine turtles in Ghana dates back to Irvine (1947). Five species of marine turtles are known to occur in Ghana's territorial waters. These include the Loggerhead, Green, Hawksbill, Olive ridley and the Leatherback turtles (Irvine, 1947; Toth and Toth, 1974; Brongersma, 1982; Armah *et al.*, 1997). The Olive ridley turtle is known to show the highest relative abundance in Ghana (Carr and Campbell, 1995). Minor nesting of the Leatherback turtle in Ghana is recorded by Mârquez (1990).

Seventy percent (70%) of Ghana's 535 km coastline presents suitable sites for turtle nesting. The shoreline from Prampram to the Volta estuary, a distance of about 65 km, however serves as the main turtle sites (Carr and Campbell, 1995). The local Ghanaian names are given as follows: Leatherback (**Ga**: Gbosange; **Fante** : Puhuru; **Ewe**: Agbosege), Hawksbill (**Ga** : Hala akoo ; **Fante** : Puhuru ; **Ewe** : Klo), The same names are used for Loggerheads, Olive ridley and Green turtles in the various dialects (**Ga** : Hala ; **Fante** : Puhuru ; **Ewe** : Klo) (Armah *et al.*,1997).

2.4 REPRODUCTION IN SEA TURTLE

According to Miller (1997), reproduction in marine turtle occurs within three general constraints. These are:

1) Nesting must occur during conditions that are "conducive to adult activity".
2) Nesting must occur during conditions that facilitate embryonic development and survival.
3) Hatchlings must emerge into conditions that "are conducive to their survival".

Within these constraints, sea turtles share a number of general reproductive characteristics. For instance, all species exhibit:

a) Iteroparous reproduction (Hirth, 1980; NRC, 1990) with possible exception of the Kemp's ridley (NRC, 1990),
b) Stereotyped nesting behaviour (Hendrickson, 1982),
c) Laying of relatively large numbers of eggs several times during the reproductive period (Hirth, 1980, Van Buskirk and Crowder, 1994; Miller, 1997).

d) Relatively strong attachment to a particular location for nesting (Bjorndal *et al.*, 1985; Limpus *et al.*, 1992) but inter- and intra- specific variations exists.

2.4.1 AGE AT FIRST MATURITY

There have been lots of speculations about the age at first maturity. Whilst some authors estimate values as low as 6 years, others state between 8 and 13. According to Márquez (1990), studies using average sizes instead of the smallest sizes of turtles estimated age at first maturity for Green turtles between 25 and 30 or more years. Limpus (1990), using a laparoscope (a fiberoptic instrument used to examine visually the interior of the peritoneal cavity) followed the maturation (changes in oviduct and ovaries, testis and epididymis) of *C. caretta* in foraging areas of eastern Australia. His results showed that Hawksbill, Green and Loggerhead turtles typically begin breeding at just less than a few centimetres longer than the minimum breeding size and still immature or just starting into puberty. Presumably, other species show similar patterns of maturation. This shows that size is not a reliable indicator of maturity or breeding.

Sea turtles must have access to beaches with deep, loose sand that are above high tide for nesting. They nest predominantly during the warmer months. Some beaches are known to host year-round nesting. The incubation of sea turtle eggs is dependent on the temperature of the sand, hence, the duration at which the embryos develop and the hatching period show wide variations. Cooler sand has been found to produce more males, with warmer sand producing a higher ratio of females (Caribbean Conservation Corporation, 1996).

2.4.2 COURTSHIP BEHAVIOUR

Male and female exhibit courtship behaviours prior to mating. In the male, precopulatory behaviours include head bobbing, position in the water column, head to head bumps, nuzzling, biting, movement of flippers. During courtship, a female receives bites (nips) to her flippers, neck and head that leave open sores for several weeks to heal.

The male mounts the female usually at the surface with a lot of splashing and hooks onto her carapace using the enlarged claws on his front flippers and the large claws on his hind flippers to hold himself in place. The male curls his long tail to bring their cloaca into contact. His penis is erected into her cloaca. The shape of the penis with a bifurcation of the sperm duct at the tip allows the transfer of semen into each oviduct without passing through the environment of the female's cloaca. According to Wood and Wood (1980) an increase in fertility correlated with the duration of the coupling period. Genetic studies have shown that males mate with several females and females mate with several males (Miller, 1997).

2.4.3 NESTING PERIODICITY

Generally, female sea turtles do not reproduce every year, with the exception of *L. kempi*. Males of some species (e.g. *C. caretta*) however, may mate every year or every two years. While in foraging areas, sea turtles accumulate the energy reserves required to support vitellogenesis over a variable period of several years depending, in part, on the quality and quantity of food available.

Several clutches of eggs are laid at approximately two weeks intervals. This greatly reduces the likelihood of all eggs being lost during the breeding period. The ecological consequences of this behaviour require elucidation, but it is clear that the turtles are spreading their reproductive effort through time which reduces impact of an unpredictable environment on hatchling production (Eckert, 1987).

When a set of exogenous (e.g. photoperiod) and endogenous (e.g. hormone levels and / or fat levels) factors interact, the consequence is reproduction. The timing of reproduction in marine turtles follows behind period of ample food availability during which the turtles accumulate fat reserves (one to several years), complete vitellogenesis (10 - 12 months) and migrate to the breeding and nesting area.

2.4.4 NEST SITE FIDELITY

All eight species nest on beaches around the world. The species migrate from foraging grounds to mating grounds a short distance away. After mating, the females then migrate to nesting areas while males return to foraging grounds. After a reproductive period, the females return to the foraging grounds and prepare for the next reproductive period, a few to several years in the future.

Tag-return data have established that some turtles migrate over distances greater than 2600 km, however, most travel less than 1000 km. All species migrate to varying degrees except the *N. depressus* that does not migrate beyond the continental shelf of Australia. Carr (1975) made the distinction between regional discrimination (philopatry) and fine-scale homing to beach (site fidelity) within the region for sea turtles. It is now well established that marine turtles migrate between their foraging areas and their nesting areas with a high degree of accuracy (Limpus *et al.*, 1992; Limpus and Miller, 1993).

Although they may not necessary return to the beach of their birth, genetic studies have demonstrated that breeding sea turtles return to the region of their birth (Miller, 1997; Bowen *et al.*, 1992). Once a turtle returns to the region of its birth and selects a nesting beach, it will tend to renest in relatively close proximity (0 to 5 km) during subsequent nesting attempts within that nesting season. Limpus *et al.* (1984) reported that *N. depressus* returned to the nesting beach with a high degree of accuracy regardless of whether they were returning after an "unsuccessful" nesting (or) in later breeding season. Green turtles are known to show a high degree of nest site fidelity. Bosc and Le Gall (1986) reported that most renesting attempts were within 200 m of the previous attempt, with a range of about 600 m over a three-month nesting season.

CHAPTER THREE

MATERIALS AND METHODS

3.0 STUDY AREA

Ghana is located in West Africa on the Gulf of Guinea. The coastline is generally low lying; not more than 200m above sea level (Armah and Amlalo, 1998) and is characterised by sandy beaches, rocky beaches and rocky headlands. The continental shelf is narrow. It extends between 20 km and 35 km except off Takoradi where it reaches 90 km. The coastal waters are characterised by two seasonal upwellings with varying annual intensities. The bottom is varied consisting of sandy, muddy and rocky portions.

The entire 550 km coast of Ghana was investigated, visiting a total of 23 beaches with average interval of about 21 km. The beaches along Prampram through New Ningo to Old Ningo in the Greater Accra region, east of Accra were selected as an intensive study area. This was based on preliminary investigations involving visits to beaches and interviews. This area has been described as the prime nesting site of marine turtles. This confirmed earlier assertions by Toth and Toth (1974) and Carr and Campbell (1995). The shoreline of the intensive study area is characterised by gently sloping fine to coarse sandy beaches. Partially submerged rocks are observed intermittently in some parts of the sublittoral zone and the intertidal.

The vegetation along the beach is of the strand type and includes *Sporobolus* sp., *Ipomea pes–caprae, Sesuvium portulacastrum, Cyperus maritimus, Canavalia rosea* among many others. *Cocos nucifera*, however, dominates the entire coastline in size and height.

3.1 DATA COLLECTION

Three major methods were employed in data collection viz questionnaires, sediment granulometry and field observations of nesting turtles.

3.1.1 USE OF QUESTIONNAIRES

Questionnaires were administered along the entire coast of Ghana; from New Town on the extreme west near Half Assini to Denu on the east (Figure 1). This was to find out the perceptions of the fishers of sea turtles especially their knowledge on nesting locations. Fishermen were interviewed in groups between 5-15 men at a time on the canoe landing beaches.

Within the intensive study area comprising Prampram, New Ningo and Old Ningo 50 questionnaires were administered. The questionnaires were analysed using the computer program 'Statistical Package for Social Sciences' (SPSS).

3.1.2 SEDIMENT GRANULOMETRY

In order to establish whether sediment type could influence choice of nesting locations, sand samples were collected at about 40 cm deep from all the beaches visited and analysed. Sub-samples were weighed from each sand sample, washed in distilled water for 10 minutes using a 63 μm mesh sieve to remove the silt-clay fraction as outlined by Gray (1981). The washed sub-samples were dried at 100°C overnight (about 16 hours).

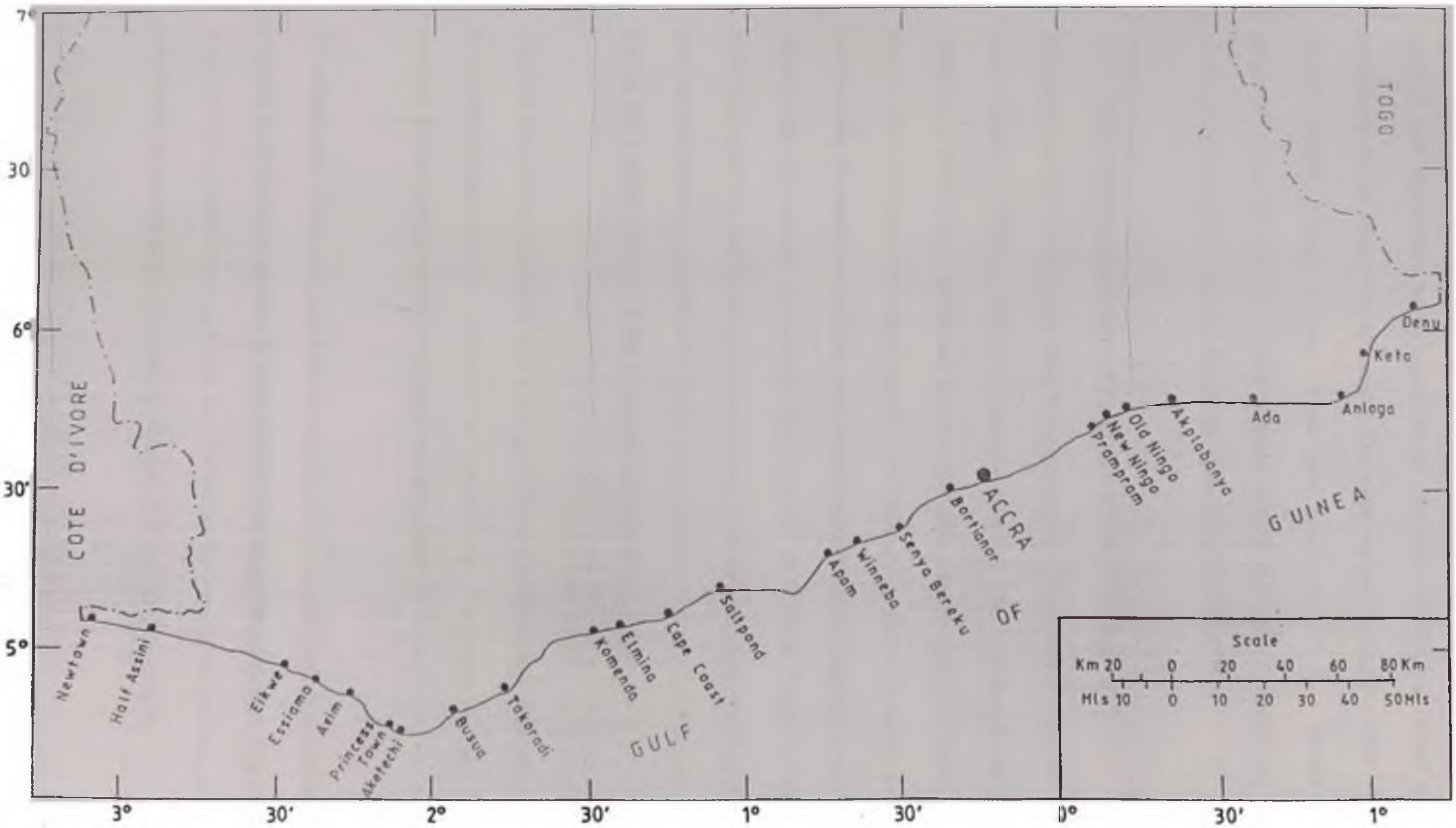

Figure 1 Map of Ghana showing various sampled stations

100g of each sub-sample was weighed on an electronic balance and shaken by a mechanical shaker with series of screens. The mesh sizes of the screens were 1mm, 710µm, 500µm, 355µm, 250µm, 125µm, and 63µm arranged in a decreasing geometric scale. The amount of sand retained on each sieve was weighed and the median grain size of each sample determined from a cumulative plot.

3.1.3 FIELD OBSERVATIONS AT INTENSIVE STUDY AREA

The approximately 15 km beach from Prampram to Old Ningo was divided into six zones (Zone A- F, Figure 2). These beaches were patrolled daily from August 1998 to April 2000. Patrols were conducted on foot, just after sunrise for best viewing of crawls. This is because track signs begin to deteriorate as the sun dries out the sand, and the crisp shadows that facilitate track identification are lost. Complete counts of nesting and non-nesting emergences (false crawls) were done. Track of each individual turtle was identified by its shape (design), measured and nest marked with pegs as well as taking co-ordinates using a Global Position System (GPS). Dates of nesting and hatching were recorded to estimate the emergence period.

All nests were left to develop *in situ*, and eggshells from hatched eggs were gathered by excavating each nest four days from the hatched date. The number of eggs that were not hatched in each nest were counted and recorded.

To estimate the clutch size, eggshells were gathered from each nest, sun-dried and weighed on an electronic balance to estimate the clutch size of each species. The total weight of the eggshells from each nest was divided by the average weight of a small sub-sample of hatched eggs. This enabled estimation of hatching success by

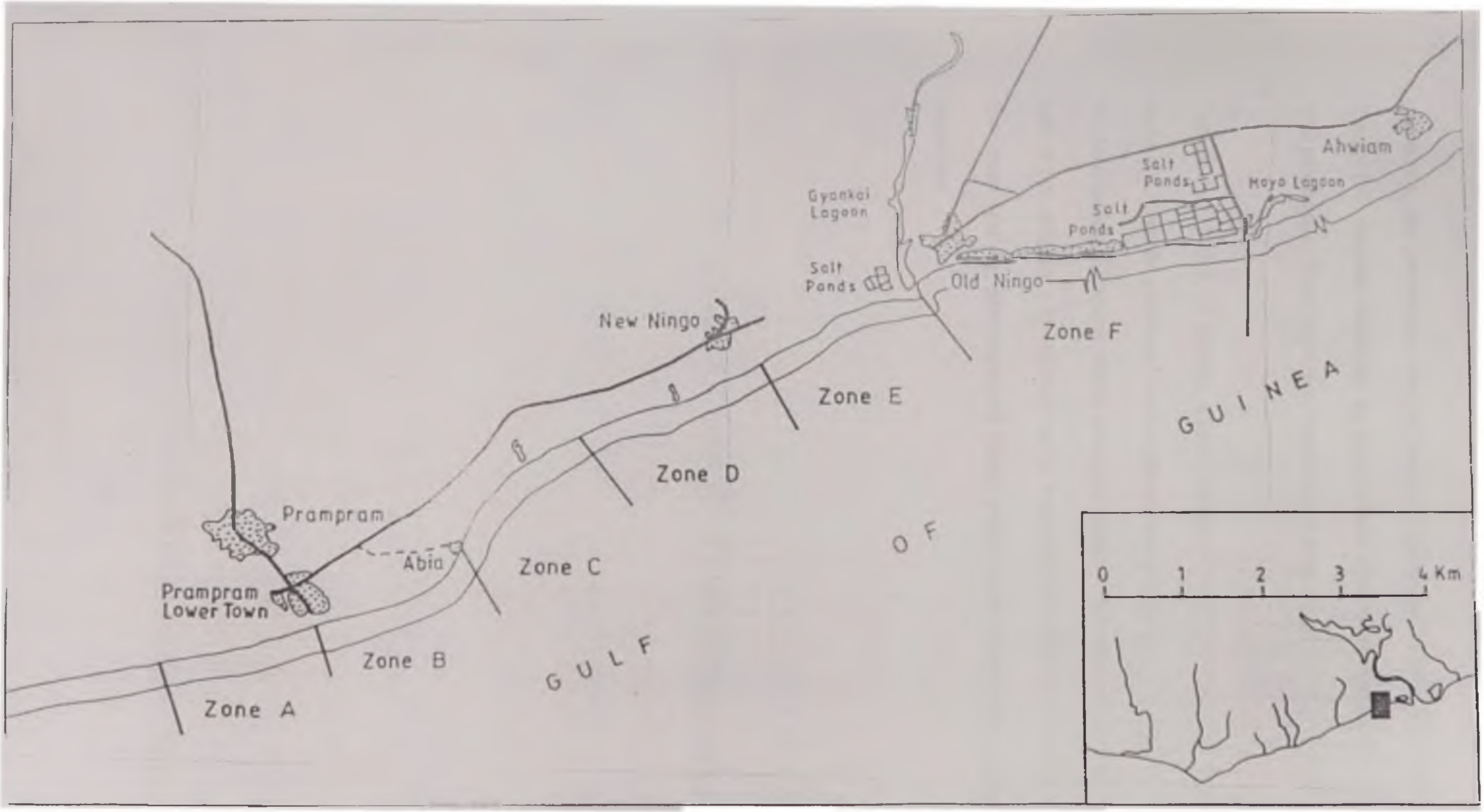

Figure 2 Map of intensive study area, showing the various zones

calculating the percentage ratio of hatched eggs to the clutch size. The number of freshly laid clutches destroyed by dogs in each zone were recorded to estimate the total percentage of sea turtle eggs destroyed by dogs during the study period.

During the 1999/2000 nesting season, carapace lengths for nesting females were measured from the precentral scute in the carapace midline to the posterior margin of the postcentrals. Carapace widths were also measured over the curve across the widest part of the carapace perpendicular to the longitudinal body axis. Counting of eggs as they were laid was also done and filmed with a night vision video camera on two occasions.

CHAPTER FOUR

4.0 DISTRIBUTION OF SEA TURTLES IN GHANA

4.1 INTERVIEW BY QUESTIONNAIRE

4.1.1 INTRODUCTION

In areas where sea turtle conservation programmes are desirable but lacking, conservationists and sea turtle researchers are faced with identifying potential study sites in the absence of field data. Some of the techniques for sea turtle habitat surveys outlined by Diez and Ottenwalder (1999) include interviewing potentially knowledgeable residents and preliminary surveys to confirm the presence of crawls, nesting pits, or egg shells on the beaches.

After Irvine (1947), other authors have also documented the occurrence of sea turtles in Ghana's coastal waters (Toth and Toth, 1974; Brongersma 1982, Groombridge, 1982; Carr and Campbell, 1995 and Armah *et al.*, 1997). Five species are known to exist in Ghana's coastal waters with the Olive ridley being the most common. However, no detailed studies on the distribution of sea turtles had been conducted in Ghana in the recent past.

4.1.2 MATERIALS AND METHOD

Questionnaires were administered to fishermen at various fishing communities along the entire coast of Ghana, about 21 km interval. A total of 97 fishermen in groups made up between 5 and 15 people were interviewed at a time. The fishermen were interviewed in local dialects: Fante, Ga, Dangme and Ewe. Series of questions addressing observations on sea turtles, such as the occurrence and seasonality of nesting were posed to obtain basic information. Care was taken not to bias the responses of interviewees.

At the intensive study area, a total of 50 questionnaires were administered to the fishermen at the canoe landing beaches. This was to compare their observations with the data collected from the field.

4.1.3 RESULTS

4.1.3.1 **Entire coast**

Interview conducted among local fishing communities along the entire coast of Ghana showed that Olive ridley is still the most common sea turtle seen (Plates 1 and 2). Respectively, 31.8%, 30.3%, and 26.4% of the respondents are very familiar with the Olive ridley, Leatherback and Green turtle respectively. About 10.1% of fishermen interviewed said they have ever seen the Hawksbill at sea while 1.4% believe they had seen the Loggerhead. The interview revealed that the nesting season starts in late August, peaks in December and ends in March. However, visits to some of the nesting beaches showed that the turtles stop nesting before mid-January.

Of the fishermen interviewed, 54.6% were of the view that the number of turtles they see these days is decreasing. However, 45.4% maintained that the numbers are almost the same in that they see turtles regularly as in the recent past during the nesting season.

Plate 1 Interviewing fishermen at New Town on the boarder with Cote D'ivore.

Plate 2 Interviewing fishermen mending their nets at Senya Bereku

Along the coast, 59.9% of fishermen interviewed have tasted and still eat sea turtle meat, of which 36.2% claimed they enjoy the meat very much, 3.4% do not enjoy it but eat when given, while 13.1% were indifferent. The turtle meat is rarely sold on the local markets. Fishmongers who buy the turtles, smoke the meat for sale at markets hinterland. The percentage of respondents who have tasted and still eat sea turtle eggs was 69.5. As high as 79.6% of the fishermen interviewed confirmed that sea turtles are still landed by some fishermen along the coast. Only 1% of those interviewed said they were aware that sea turtles play important role in the marine ecosystem.

Out of the interviewees, 88.9% suggested that dogs must be killed at the beaches in order to protect sea turtle eggs. Destruction of sea turtle eggs by dogs and pigs is not a major problem along most of the nesting beaches, only 15.2 % of the fishermen interviewed along the entire coast said they are aware that dogs and pigs destroy sea turtle eggs.

Concerning prohibition by law, 31.4% of those interviewed said they were aware that it was illegal to capture sea turtles or collect their eggs. A higher proportion of 45.7% of the total respondents expressed willingness to join any sea turtle management committee, 53.3% were indifferent but would participate if given incentives, while only 1.0% said they would not join.

The questionnaire evaluation revealed that other potential nesting sites in Ghana are PrincessTown, Elmina, Gomoa-Fete, besides Prampram, Old Ningo, Akplabanya, Ada, Anloga and Keta. Also, sporadic nesting occurs on most of the sandy beaches along the Ghana shoreline (Figure 3).

4.1.3.2 **Intensive Study Area**

At the intensive study area, 41.2% of those interviewed were very familiar with the Olive ridley, 35.3% with Leatherback and 17.6% with the Green turtle. From the questionnaire evaluation, the nesting season was placed between September and February. At Old Ningo, New Ningo and Prampram, 80% the fishermen believe the number of nesting turtles have increased in recent times. At Old Ningo and New Ningo, none of the fishermen admitted ever tasting sea turtle meat. However, at Prampram 50 % of those interviewed had tasted sea turtle meat. According to the fishermen, no turtle have ever been landed by any of them on the beach in recent times (the past two years). On the threat posed by dogs to turtle nests, 40.6% of the interviewees at Prampram, 87.5% at New Ningo and 100% at Old Ningo agree that destruction of sea turtle eggs by dogs is a major problem in their local communities.

4.1.4 DISCUSSION

The aim of the questionnaire, *inter alia*, was to ascertain:

i) nesting sites

ii) familiarity of coastal fishers with species of sea turtle in Ghana

iii) extent to which they are used as food by coastal dwellers and its legality

iv) potential and actual non-human predators of turtle eggs

v) willingness of coastal communities to conserve sea turtles.

Sporadic nesting	1
Moderate nesting	2
High nesting	3
Very high nesting	4

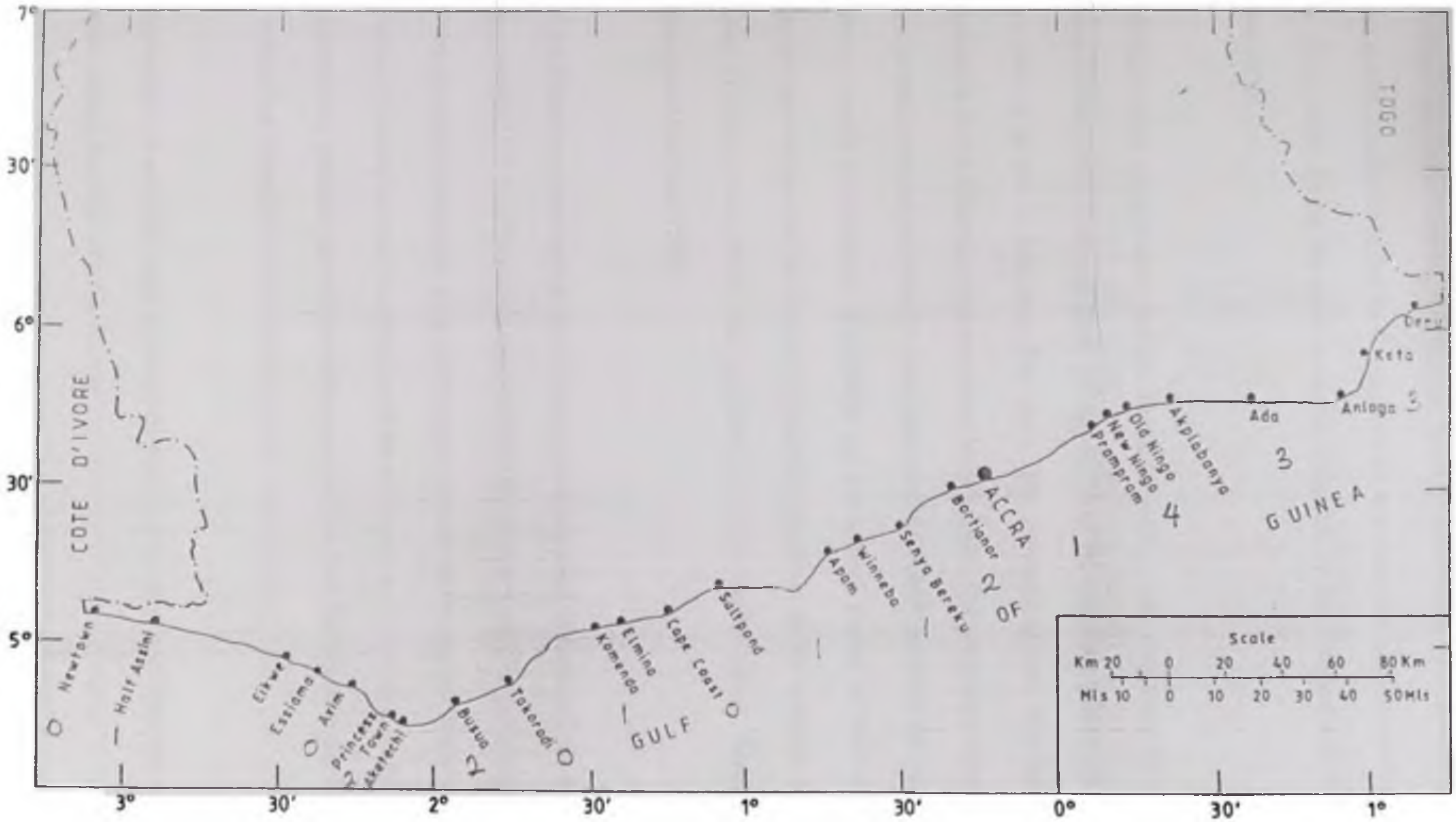

Figure 3 Map showing sea turtle nesting activity along the coast of Ghana.

Interviews conducted among the various fishing communities have shown that the Olive ridley, Leatherback and the Green turtle all nest along the entire coast of Ghana. The Olive ridley being the most common, followed by the Leatherback, then the Green turtle.

Although earlier records show that the Hawksbill turtle is very rare along the coast of Ghana (Irvine, 1947; Toth and Toth, 1974), 10.1 % of the total respondents claim they have seen it at sea in less than five years. The presence of very few individual Hawksbills in the Ghanaian waters cannot be ruled out. The Ghanaian waters could have served as migratory route for some individual hawksbill turtles in the past. This, however, needs confirmation. Hawksbills are not entirely absent in West Africa as they are reported to nest in relatively appreciable numbers on the volcanic island of Bioko (Tomás *et al.*,1999), and probably on Cape Verde Island, Senegal and Mauritania (Márquez,1990).

Of the fishermen interviewed, 59.9 % have tasted and most of them still eat sea turtle meat, while 15.2 % of those interviewed were aware that it was illegal to capture sea turtles or collect their eggs. Also, 79.6% agree that sea turtles are still landed on their beaches. This implies that poaching activities will continue if education on the need to conserve this resource as well as enforcement of the law that protects sea turtles in Ghana is not intensified in the coastal fishing communities.

Destruction of sea turtle eggs by dogs and pigs is not a major problem along the sea turtle nesting beaches with the exception of the stretch from Prampram to Old Ningo where the problem is with the dogs and Lekpoguno where pigs destroy the eggs.

It is however, encouraging that as much as 45.7% of the interviewees expressed willingness to join any sea turtle management committee that will be established in their local communities. On the other hand, 53.3% of the respondents said they would join if given some incentives. This is also a good sign, in that with some form of incentives, an overwhelming majority will be attracted to help protect sea turtles in their local communities.

The fact that most of the fishermen in the intensive study area are of the opinion that the numbers of nesting sea turtles on their beaches have increased in the past few years is good news for both conservationists and fisheries managers. It is not really clear as to whether this assumption is true or not. A complete estimation and monitoring of nesting sea turtle populations along the entire coast of Ghana is therefore necessary in the near future.

If it is true that no fisherman had landed any sea turtle on the beach at Prampram in the past two years as the fishermen claimed then it means that earlier education efforts by the NGO, Resource and Environmental Organization (REDO) which began in 1996 at Prampram, has been successful (Armah *et al.*, 1997). It also has promoted the compliance of the Wildlife Conservation Regulations, 1971; L.I 685 which protects sea turtles in Ghana. Most of the fishermen suggested that dogs found destroying sea turtle eggs at the beach should be shot dead. Others are of the view that the dogs should be poisoned. The shooting of dogs at the beach will be very dangerous in that one might mistake a human poacher for a dog.

The poisoning of dogs at the beach will not be easy to implement. A better option would be to protect nests with wire mesh enclosures ensuring that the mesh sizes are big enough to allow the passage of hatchlings. In such cases the beaches should be patrolled every morning to free any stranded hatchling.

4.2 BEACH SEDIMENT CHARACTERISTICS AND DISTRIBUTION OF SEA TURTLES IN GHANA.

4.2.1 INTRODUCTION

Laboratory studies have shown that temperature, gas diffusion and available moisture are the three main factors that influence the survival of reptilian eggs (Packard and Packard, 1988). However, these factors are complicated by the physical characteristics of the substrate. On a typical sandy beach the coarsest particles are found at the top of the beach and graded down to the finest sediments at the water line. This is because the upper shore of the beach is dry where there is much windblown sand, because coarse sands drain rapidly, whereas at the lower shore the sediments are wet. According to Gray (1981), coarse sediments occur at the upper shore because as the waves break on the beach the heaviest particles sediment out first. The finer particles remain in suspension longer and are carried seaward on the wave backwash. Several factors, including current speed, the roughness of the sediment and the length of time when conditions are still for the particles to settle down account for the type of deposit. Sediments are not made up of uniform particle size. They contain mixtures of grain sizes. The degree of mixing of the different types can be represented by a sorting coefficient, which is a measure of the uniformity of the particle sizes. Well-sorted sediments tending towards homogeneity are typical of high wave and current activity (high-energy areas), whereas poorly sorted sediments are heterogeneous and are typical of low wave and current activity (low-energy areas). In other words, well-sorted substrates are composed of uniform particle sizes, whereas poorly sorted substrates are composed of particles with a wide range of sizes. Wave action and current velocity are therefore the two most important factors determining the grain-size distribution and sorting coefficients of nearshore sediments.

The geographic location, rates of precipitation and characteristics of the water table may have tremendous effect on both water availability and gas diffusion in the beach sand which may influence hatching success. According to Buchanan and Kain (1971), two sediments with disparate grain size characteristics will, in most cases also show demonstrable and related differences in many other physical and biological properties, such as bulk density, capillarity, thixotrophy, permeability, oxygenation, plasticity, content and nature of organic matter and bacterial count.

In a study on nesting beaches at Ascension Island, Mortimer (1982) showed that sea turtles do not use sand texture as criteria in their choice of beach. This was because there was no correlation between percent hatching success and nesting density. However, sand texture and hatching success were related. Furthermore, some turtles even laid in sand that produce 0 % hatching success. Also when a turtle fails in her effort to construct a nest, she usually tries again only a few meters away from her aborted nest hole instead of returning to sea to look for a new beach. Some turtles were said to spend the night on the beach digging as many as 12 trail nest holes (Mortimer, 1981; Mortimer and Carr, 1987). After failing to nest, turtles normally re-emerge onto the same beach the following night (Mortimer and Portier, 1989). A study of beaches around the world had provided further evidence that green turtles do not use sand texture as criteria in their choice of nesting beach. Mortimer (1982) therefore defines "Good" sand as one that provides proper temperature, allows adequate gas exchange and provides the eggs with sufficient moisture.

Two parameters of particle size distribution are mean particle diameter and sorting coefficient. Particle size distribution and particle shape interacts to determine the pore spaces between the sand grains. The amount of pore space and the shape of the pores in the sand affect both gas diffusion and water conductivity. That is, very small pores can have a capillary effect and retain water. The amount of water in the sand affects gas diffusion, while the rate of gas diffusion in turn affects water availability, since water can be removed in its gaseous phase. Too much gas can cause desiccation of the sea turtle eggs. Chemically, some minerals of sand are hydrophilic and water adheres to their surface making water less available to the eggs. On the other hand, hydrophobic sand minerals repel water making it available to the eggs (Mortimer, 1982). Several sea turtle studies have characterised nesting beaches based on features such as grain size, beach profile and vegetation (Diez and Ottenwalder, 1999).

4.2.2 MATERIALS AND METHOD

Sand samples were collected at about 40cm deep from all the beaches visited. Sub-samples were weighed from each sand sample, washed in distilled water for 10 minutes using a 63 µm mesh sieve to remove the silt-clay fraction as outlined by Gray (1981). The washed sub-samples were dried at 100°C overnight (about 14 hours).

100g of each sub-sample was weighed on an electronic balance and fractionated in a mechanical shaker with series of screens. The mesh sizes of the screens were 1mm, 710µm, 500µm, 355µm, 250µm, 125µm, and 63µm arranged in a decreasing geometric scale. The amount of sand retained in each sieve was weighed and the median grain size of each sample determined from a cumulative plot. The cumulative frequency was plotted showing the percentage of sediment (from coarsest to finest) on the ordinate and the sieve size on the abscissa. The intercepts of the 5, 16, 50, 84, and 95 percentiles with the cumulative curve were used to calculate the sorting coefficient using the Inclusive Graphic Standard Deviation (σ_I).

Where $\sigma_I = (ø84 - ø16)/4 + (ø95 - ø5)/6.6$

The sorting classes produced by this index is given as:

Under 0.35	very well sorted
0.35-0.50	well sorted
0.50-0.71	moderately well sorted
0.71-1.00	moderately sorted
1.00-2.00	poorly sorted
2.00-4.00	very poorly sorted
Over 4.00	extremely poorly sorted

The Inclusive Graphic standard Deviation (σ_I) was used in the calculation of the sorting coefficient because according to Gray (1981), this formula covers over 90% of the distribution.

Sediment type was characterised using the phi (ø) scale or grain size as below:

Grain size (mm)	phi (ø) scale	Type of sediment (A)	Type of Sediment(B) (Classification by student)
256	-8	Cobble	
64	-6	Cobble	
16	-4	Pebble	
4	-2	Pebble	
2	-1	Granule	
1	0	Very coarse sand	Coarse (C)
0.5	1.0	Coarse sand	
0.25	2.0	Medium sand	Medium (M)
0.125	3.0	Fine sand	Fine (F)
0.0625	4.0	Very fine sand	
0.031	5.0	Coarse silt	
0.0039	8.0	Silt	
0.002	9.0	Silt	
0.00006	14	Clay (Buchanan and Kain,1971; Gray,1981).	

Finally, the Bray-Curtis similarity index was used to discriminate between stations with similar sediment characteristics. The software, PRIMER, was used to generate a dendrogram.

4.2.3 RESULTS

The median grain size of the various sand samples collected from the beaches along the entire coast of Ghana is shown in Table 1. Sediment obtained from Essiama was very fine with median grain size of 0.06mm, and recorded 3.99 on the phi-scale (Table 1). Fifteen (15) stations (65.22 %) out of the 23 stations sampled had sediments ranging between medium sand and coarse sand. Sediment from Keta and Denu were coarse and that from Bortianor was rated as very coarse sand. Stations with fine or very fine sand constituted 34.78 of the shoreline.

Results obtained from the particle size analysis of the sediment from the various sampled stations showed that about 86.96% of the total have sorting coefficient between 0.4 and 0.9 i.e moderately to well-sorted sediment (Figure 4). Three stations have very well sorted (< 0.35) sediments. These were Essiama, PrincessTown and Akentechi. It must be emphasized that in the case of Essiama, the value was zero. Salt Pond, Apam and Denu have sorting coefficient between 0.35 and 0.5 and classified as well sorted. Ten stations (43.48%) have sorting coefficient between 0.5 and 0.71, These were moderately well sorted. Seven stations (30.44%) have moderately sorted sediments (Figure 5).

Table 1 Sampled beaches, showing sediment type and nesting activity

STATION	Serial No.	Sorting coeff.	Median grain size	Phi scale	Sand type	Nesting activity
NEW TOWN	1	0.63	0.13	3.00	F	0
HALF ASSINI	2	0.76	0.25	2.00	M	1
EIKWE	3	0.8	0.25	2.00	M	0
ESSIAMA	4	0	0.06	3.99	F	0
AXIM	5	0.88	0.13	3.00	F	0
PRINCE'S TOWN	6	0.3	0.13	3.00	F	2
AKENTECHI	7	0.3	0.13	3.00	F	2
BUSUA BEACH	8	0.55	0.13	3.00	F	2
TAKORADI	9	0.88	0.13	3.00	F	0
KOMENDA	10	0.88	0.25	2.00	M	1
CAPE COAST	11	0.68	0.36	1.49	MC	0
SALT POND	12	0.48	0.25	2.00	M	1
APAM	13	0.48	0.13	3.00	F	1
WINNEBA	14	0.68	0.36	1.49	MC	1
SENYA BEREKU	15	0.68	0.25	2.00	M	1
BORTIANOR	16	0.88	0.71	0.49	C	2
PRAMPRAM	17	0.63	0.25	2.00	M	4
OLD NINGO	18	0.63	0.36	1.49	MC	4
AKPLABANYA	19	0.63	0.36	1.49	MC	3
ADA	20	0.55	0.36	1.49	MC	3
ANLOGA	21	0.88	0.5	1.00	C	3
KETA	22	0.55	0.25	2.00	M	3
DENU	23	0.48	0.5	1.00	C	3

No nesting activity	0
Sporadic nesting activity	1
Moderate nesting activity	2
High nesting activity	3
Very high nesting activity	4

Sand type
C = Coarse
MC = Medium-Coarse
M = Medium
F = Fine

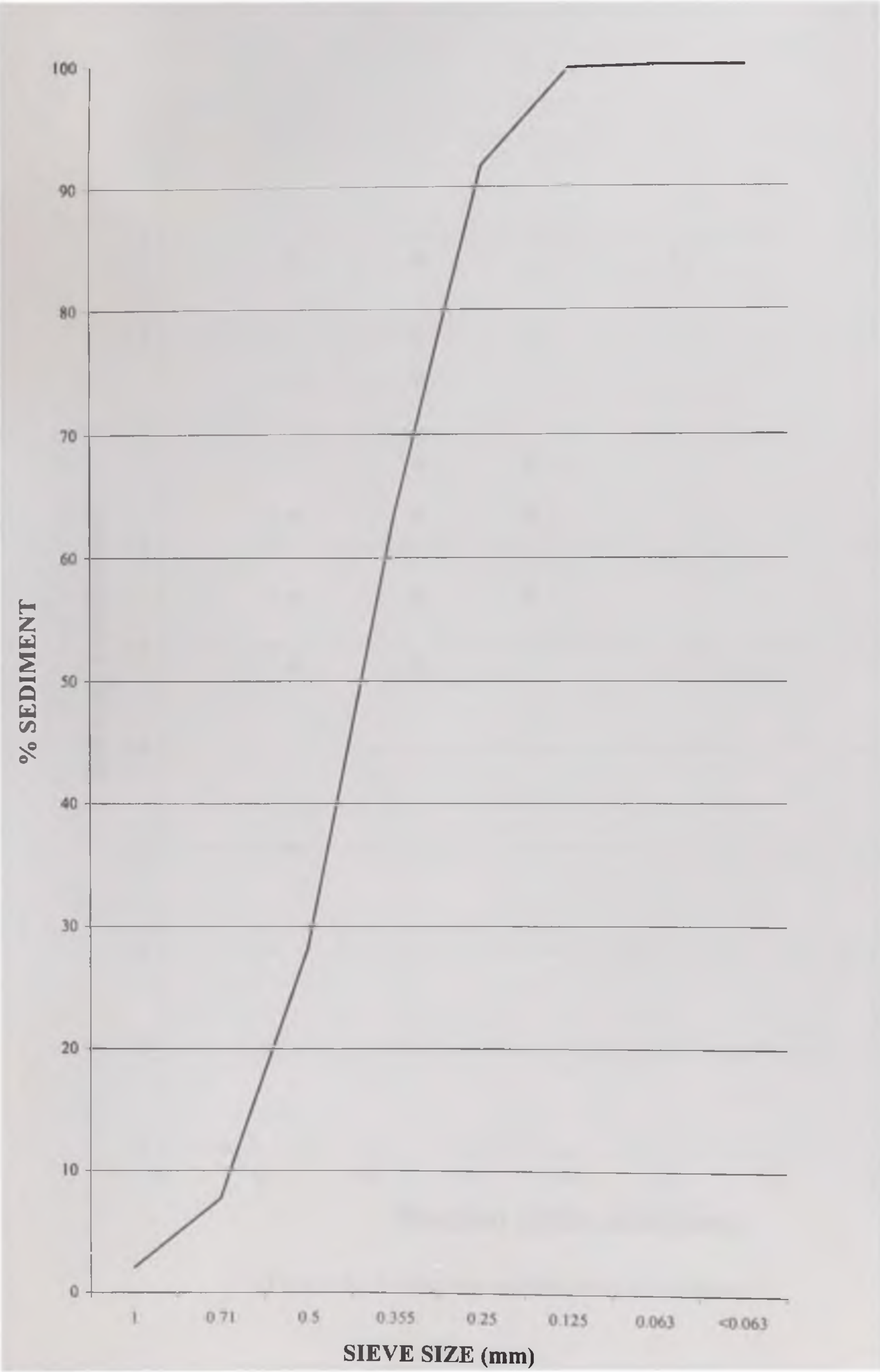

Figure 4 Cumulative plot for sediment from Old Ningo beach

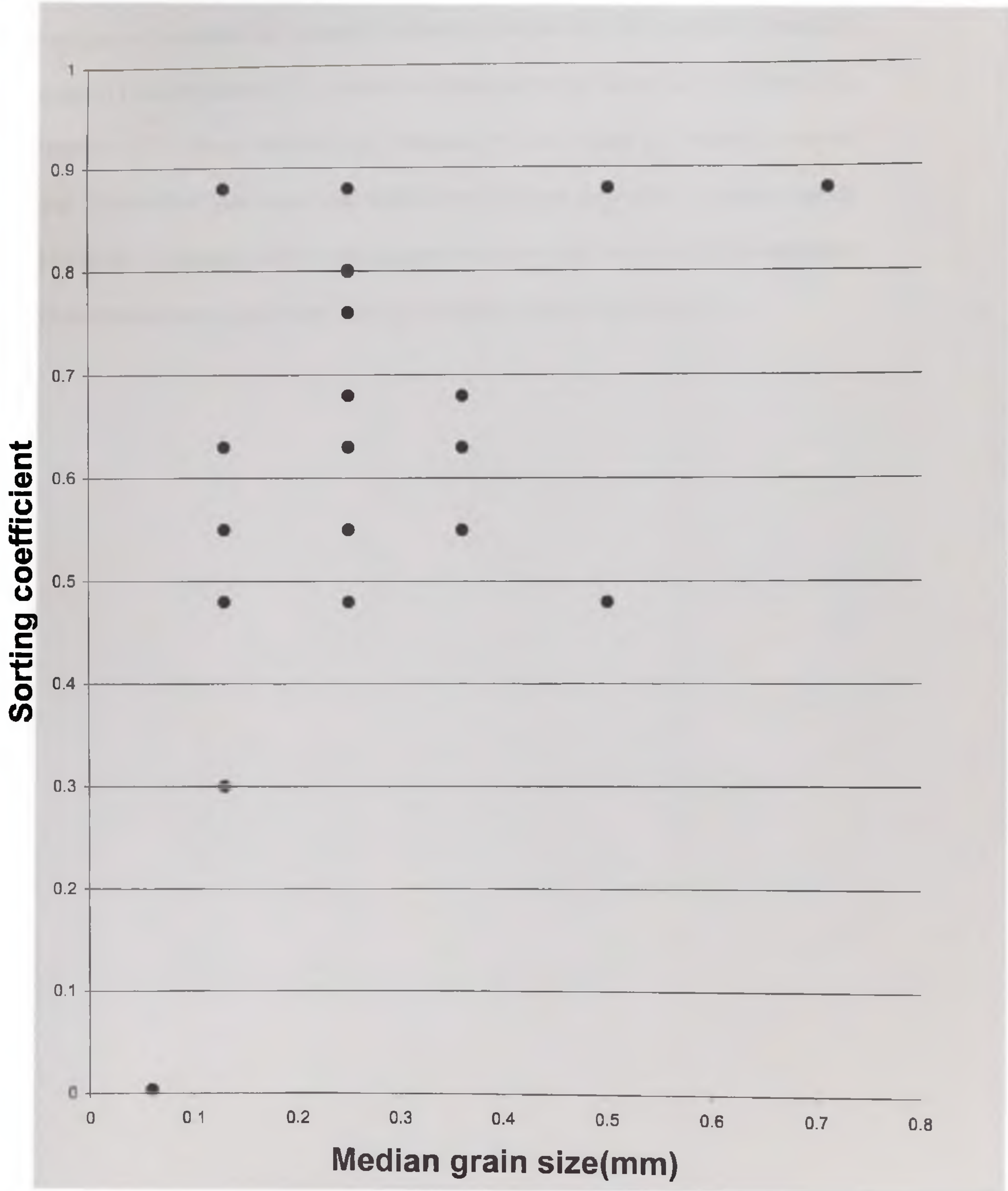

Figure 5. Grain size versus sorting coefficient

The dendrogram generated using the Bray-Curtis similarity index showed clear groupings and overlaps of sampled sediments (Figure 6). For example, Denu(23), Anloga(21) and Bortianor (16) clustered to form one group. Keta (22), Salt Pond (12), Prampram (17), Senya Bereku(15), Takoradi (9) and Axim (5) formed a second group. Three other groupings with distinctive sediment properties are shown on the dendrogram. In general, the results suggest a west to east trend of beach sediments with increasing mean grain size. No clear trend for sorting was evident.

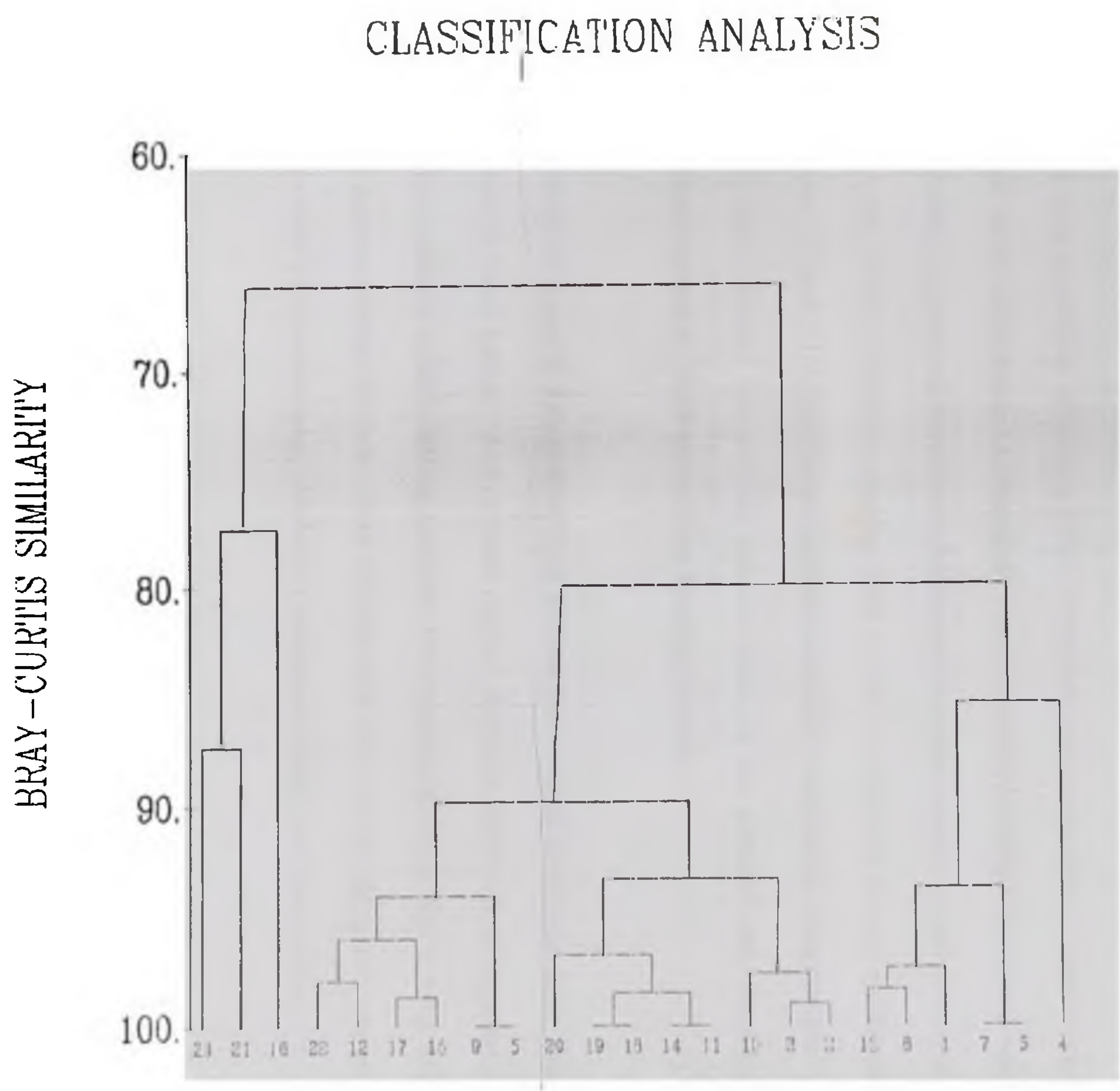

Figure 6 Dendrogram showing classification analysis of sand samples from various beaches

4.2.4 DISCUSSION

Long stretches of sandy beaches occur from the extreme west bordering Cote d'ivore to Axim, and from Prampram to Aflao on the east (Armah and Amlalo, 1998). However, the occurrence of several kilometers of sandy beaches does not necessarily guarantee the existence of suitable nesting sites. Sea turtles nest on beaches with a range of physical characteristics of beach sediment. These include mean particle size and sorting coefficient. Mortimer (1982) found that green turtles nest in sands having a wide variety of textures. At Ascension Island, sands that produced the highest rates of hatching success and which were the easiest for nesting females to construct nests had mean particle diameters ranging from 0.4 to 1.0 mm and sorting coefficient between 0.5 and 1.1. Other factors such as patterns of precipitation, characteristic of water table, mineral composition and the shape of the particles may introduce additional variables, which could affect hatching success.

As shown in figure 5, most (82.61%) of the beaches sampled have mean grain sizes between 0.1 and 0.4mm. Most of these beaches therefore might not be expected to support moderate to high nesting activities. For example, at Old Ningo, a town with high nesting activity, the mean grain size was 0.36 mm, and sorting coefficient was 0.63 which is within the range obtained at Ascension Island by Mortimer (1982).

From interviews conducted, sporadic sea turtle nesting activities occur along some of the beaches between New Town and PrincessTown. At Essiama the sediment was very fine and wet making it very compact. This is certainly not good for nest construction. One fisherman said he had once witnessed a turtle trying to dig a nest but abandoned it half way and returned to sea. Moderate nesting of Olive ridley and

Leatherbacks occur on beaches from PrincessTown to Dixcove, as well as sporadic nesting by the Green turtle (Figure 3). No nesting is known around Takoradi, but sporadic to moderate nesting occurs between Takoradi and Winneba. Moderate nesting occurs beyond Winneba through Bortianor to some beaches around Accra such as Gbegbeseh and Sakumono. Some hatchlings were picked from Sakumono beach in January, 2000 by national service personnel from the Department of Oceanography and Fisheries (University of Ghana) during a field trip.

Most of the nesting activities occur from Prampram to Ada, and after the Volta estuary to Denu. Green turtle nesting along the coast of Ghana was found to be low, however, constant monitoring of this species would provide a clearer picture. It was surprising that most of the beaches (medium to coarse) provide nesting habitat for the Leatherback. The nesting population of this species is certainly higher than previously anticipated.

Sea turtles are said to have difficulty constructing suitable nests in beaches composed of coarse, dry sand. The tendency to dig multiple nest holes and to re-emerge on successive nights also has been reported at the coarse-grained beaches of French Frigate shoals, on the Great Barrier Reef of Australia (Bustard and Tognetti, 1969). On the other hand, sea turtles do not normally construct more than one egg chamber on the fine-grained nesting beach at Tortuguero, Costa Rica before laying their eggs. At Bortianor, Anloga and Denu where the sand textures were coarse, these areas turned out to be good sea turtle nesting sites.

According to Packard and Packard (1988), sea turtles do not actually use sand texture for choice of nesting beach but may rely on temperature, moisture and respiratory gases that are considered the most important physical variables that affect the survival of reptilian embryos. This assertion is not supported by the result from this study because no nests were seen in areas composed of very fine (Essiama) and fine (Axim) in the course of this study. Temperature was not considered in this study due to lack of appropriate soil thermometer. One soil thermometer was used during the 1997/98 nesting but was discontinued because it was too short and could not measure temperatures deeper than 30 cm. However, the average temperature measured was 29°C.

CHAPTER FIVE

5.0 REPRODUCTIVE ACTIVITY OF SEA TURTLES IN THE INTENSIVE STUDY AREA

5.1 INTRODUCTION

The nesting seasons for sea turtles appear to vary with species and geographic location. With the Olive ridley, this occurs mainly in summer and autumn, however, variations exist from place to place. In Mexico and Central America it is known to extend from June or July to November or December. In Surinam, from April to September, in Cape Verde and Senegal from May to August, and in Northeastern India it occurs from February to June (Màrquez, 1990).

Nesting season of Green turtle varies in time among distant and near localities due to their wide distribution range. For instance, In the Southeastern Atlantic Ocean, it occurs from November to February in the Gulf of Guinea and in the Ascension Island it occurs between February and April. Nesting by the Green turtles in the Western Indian Ocean occurs throughout the year, and peaks from February to April in Aldabra Island, but around Seychelles and the Comoro Archipelago, it occurs from May to August (Màrquez, 1990).

In the Eastern Atlantic the Leatherback turtle nest from June to August in Senegal and from October to February in South Africa. In the Western Atlantic Ocean nesting is from March to July. In Colombia, French Guiana and Surinam nesting occurs from March to July, but in Guyana it is between January and March (Márquez, 1990).

Within-season, re-nesting periodicity of sea turtles occurs, as they often lay more than one complement of eggs during each nesting season. According to Márquez (1990), successive nesting within the same season occurs at two weeks intervals, most green turtles lay between 2 and 5 clutches. Some may lay only once or more than five times. For Green turtles, the consecutive nesting emergences are given as follows: Tortuguero (Costa Rica) 10.5 days, French Frigate Shoals (Hawaii) 12.1 days, Surinam 13.4 and Heron Island (Australia) 13.4 days (Mortimer and Carr, 1987). In Tortuguero, the average number of clutches laid by Green turtles is estimated as 2.8 (Mortimer and Carr, 1987). Kemp's ridley nest only 1.5 times per season, however they nest nearly every year.

Clutch sizes of sea turtles vary from species to species and locality to locality. The number of eggs laid by each Olive ridley ranges from a couple of dozens to more than 155. The mean clutch size for Olive ridley is around 109 eggs with variations among localities. For example, in Mexico the mean size is 105.3, Honduras 108.3 eggs, Costa Rica (Nancite) 105 eggs, and India 113 eggs. Small clutches may also occur as a result of interrupted nesting or the last clutch deposited by an individual in the season. For Green turtle, the mean clutch size ranges from 84.6 eggs in the Solomon Islands to 144.4 eggs in Southeast Africa. Carr and Hirth (1962) reported that successive clutch sizes laid by nesting green turtles decreased during the season. Four or five clutches are laid by the Leatherback each season with clutch sizes ranging from 61 to 126 eggs. The Hawksbill is known to have the highest mean individual fecundity among sea turtles. Figures ranging from 93 to 223 eggs for Hawksbill have been reported from Yucatan in Rio Lagartos, and from 51 to 211 in Virgin Islands (Màrquez, 1990). Age and size of sea turtle, time of the season as well as distance of migration also have influence on the clutch size.

Eggs of Olive ridley take between 45 to 65 days to hatch. The incubation period which correlates strongly with temperature and humidity varies from one nesting beach to another. In Escobilla, Mexico it is known to change along with the season. For example eggs laid between August and September hatch between 47 to 58 days. However in northern beaches such as Sinaloa, it takes between 49 and 62 days. Incubation period for Hawksbill eggs is between 47 to 75 days and that for Leatherback eggs varies between 50 to 78 days depending on temperature and humidity (Màrquez, 1990).

5.2 MATERIALS AND METHOD

The prime nesting beaches along Prampram through New Ningo to Old Ningo in the Greater Accra region, east of Accra were selected for intensive study of reproductive behaviour. This area stretches about 14 km and lies within the core nesting site of sea turtles in Ghana (Toth and Toth, 1974; Carr and Campbell, 1995; Armah *et al.*, 1997). The intensive study area was divided into six zones using physical characteristics such as the fort, lagoons and outfall along the beaches. Each zone stretches about 2 km except for zone F that is approximately 3.5 km (Figure 2).

Daily patrols were conducted from August 1998 to January 2000 in the morning. All turtle tracks in each zone were identified according to species using the track width and designs. The number of each species was then recorded. The numbers of false crawls as well as freshly laid nests destroyed by dogs were also recorded.

Important diagnostic features used to differentiate turtle tracks by species include track width, body pit depth, and whether the diagonal marks made by the front flippers are symmetrical or asymmetrical (Pritchard and Mortimer, 1999). A symmetrical track is formed when the front flippers move together synchronously to pull the turtle over the surface of the sand, resulting in a track in which the right and left halves are almost mirror images. An asymmetrical track is formed when the front flippers move alternately (right, left, right, left, etc.) to carry the turtle forward.

Species were identified based on species identification protocols outlined by Pritchard *et al.* (1983). *Lepidochelys olivacea* has tracks, which are very lightly cut, with alternating (asymmetrical) oblique marks by the forelimbs. Tail drag mark is lacking or inconspicuous. Track width is between 70-80 cm. Tracks of *Chelonia mydas* are deeply cut, with symmetrical diagonal markings made by the forelimbs. It has straight, central tail drag marks present, either as solid or broken line. Track width is typically between 100-130 cm. *Dermochelys coriacea* tracks were identified from their very deep and broad, with symmetrical diagonal marks made by the forelimbs, and usually with a deep incised median groove formed by dragging the tail. The width is between 150-230 cm. Tracks of *Caretta caretta* are moderately deeply cut, with alternating (asymmetrical) diagonal marks made by the forelimbs. Typically no tail drag mark. Track width is between 70-90cm.

False crawls (non-nesting emergences) were determined by careful examination of the entire turtle crawl. Examples of false crawls made by sea turtles include extensive wandering with no body pitting or digging; U-shaped crawl to the high tide line; considerable sand disturbance with evidence of body pitting and digging with a smooth-walled chamber and no evidence of covering. Also crawls where the relative lengths of the emerging and returning tracks of the turtle are the same. A thorough understanding of the nesting behaviour of each species is, however, critical to accurate interpretation of false crawl signs.

To estimate the emergence period and clutch size, nests were marked with wooden pegs, and dates on which eggs were laid and hatched were recorded. A method for estimating clutch size after emergence from nests was devised. With this method, marked nests were excavated a few days (3 to 5 days) after the eggs were hatched and all eggshells from each nest collected (Plates 3 and 4), sun dried, and weighed. The total weight of all eggshells from each nest was divided by the average weight of each eggshell to estimate the clutch size. Eggs that did not hatch were also counted to estimate the percentage hatching success.

5.2.1 COLLECTION OF BIOMETRIC DATA

Periodic visits to the beach at night were undertaken and sea turtles were measured to estimate the average size of each species. Both minimum curved carapace length (CCLmin) and maximum curved carapace width (CCWmax) of each turtle encountered were measured (Figure 7) and recorded. The measurement was done when the turtle had just finished laying its eggs. Nest depths and track widths were measured for both the Olive ridley and Leatherback. A simple but effective method

Plate 3 Collecting sea turtle eggshells at zone F (Old Ningo)

Plate 4 Excavating Leatherback nest at zone D (New Ningo)

was used to measure the nest depth. This was done by placing a 50 cm ruler horizontally across the edge of the nest and dipping a graduated thin rod into the turtle nest and reading the value where the rod touches the ruler. This was done just before the first egg was laid, or after the first egg had dropped. The measurements were taken quickly and carefully to avoid any disturbance to the nesting turtle. Eggs were also counted as they dropped by the aid of a touch light and also a night vision camera. Data recorded from the clutch size estimates and that counted were subjected to t-test. This was to determine the reliability of estimates made from total eggshell weights.

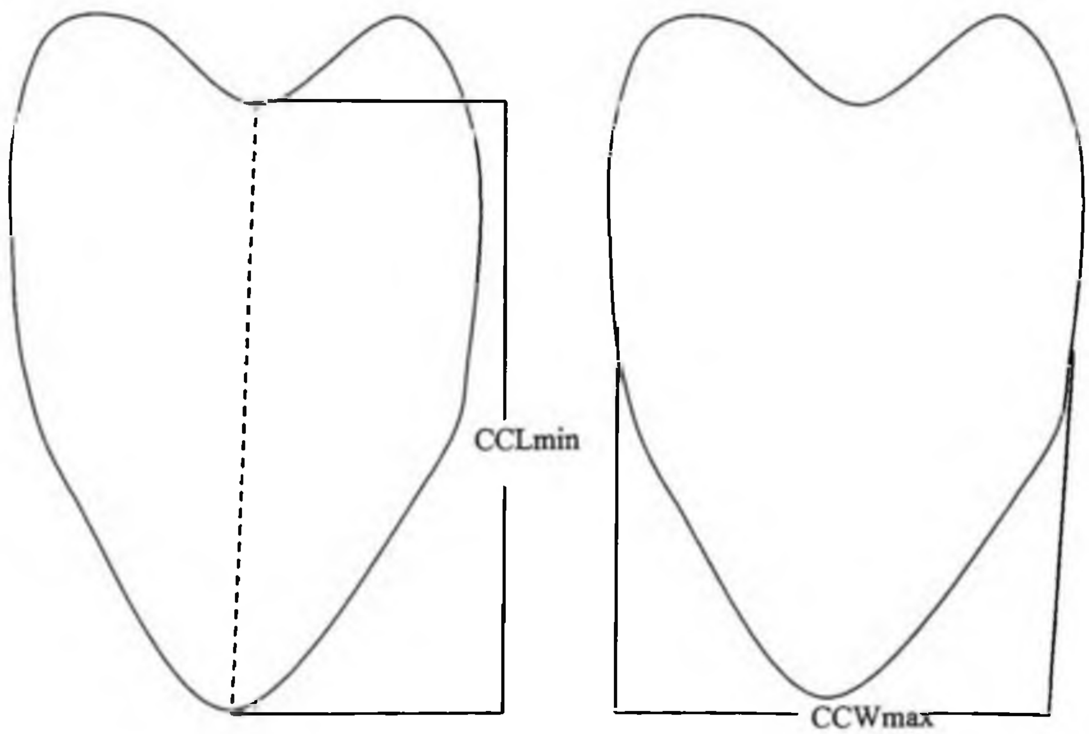

Figure 7 Method of measuring CCLmin and CCWmax.

5.3 RESULTS

5.3.1 NESTING SEASONALITY AND RELATIVE OCCURRENCE.

Figures 8 and 9 show the relative occurrence and percentage respectively of nesting species in the entire intensive study area and within the identified sub-zones/ segments. Other aspects of nesting activities such as total number of nests, percent false crawls and seasonality are presented graphically in figures 10, 11, and 12 respectively.

Results obtained from analysis of data collected during the study period, spanning the period of August 1998 to April, 2000 showed that Olive ridley (*L. olivecea*) accounted for about 91% nests. Green turtles (3%) and Leatherback turtles (6%) nest mainly from November to February. However, very few tracks (about seven per month) were recorded for Green turtles in August, September and October 1998 along the whole stretch of the beach from zones A-F. Also, two tracks of loggerhead turtle were recorded in December, 1998 at zone C. Average percentage false crawls by the nesting turtles for zones 'A' to 'F' were respectively 12.65, 28.24, 0, 7.23, 13.38 and 9.29 (Tables 2a-f).

5.3.2 EMERGENCE PERIOD, CLUTCH SIZE AND PERCENTAGE HATCHING SUCCESS

The mean emergence period for Olive ridley was found to be 52 days (SD=2.12; Table 3), Green turtle 56 days (SD=2.57; Table 4) and Leatherback turtle 62 days (SD=3.5; Table 5). Average clutch size estimates for Olive ridley, Green and Leatherback turtles were 86 (SD=12), 83 (SD=11) and 81 (SD=18) respectively

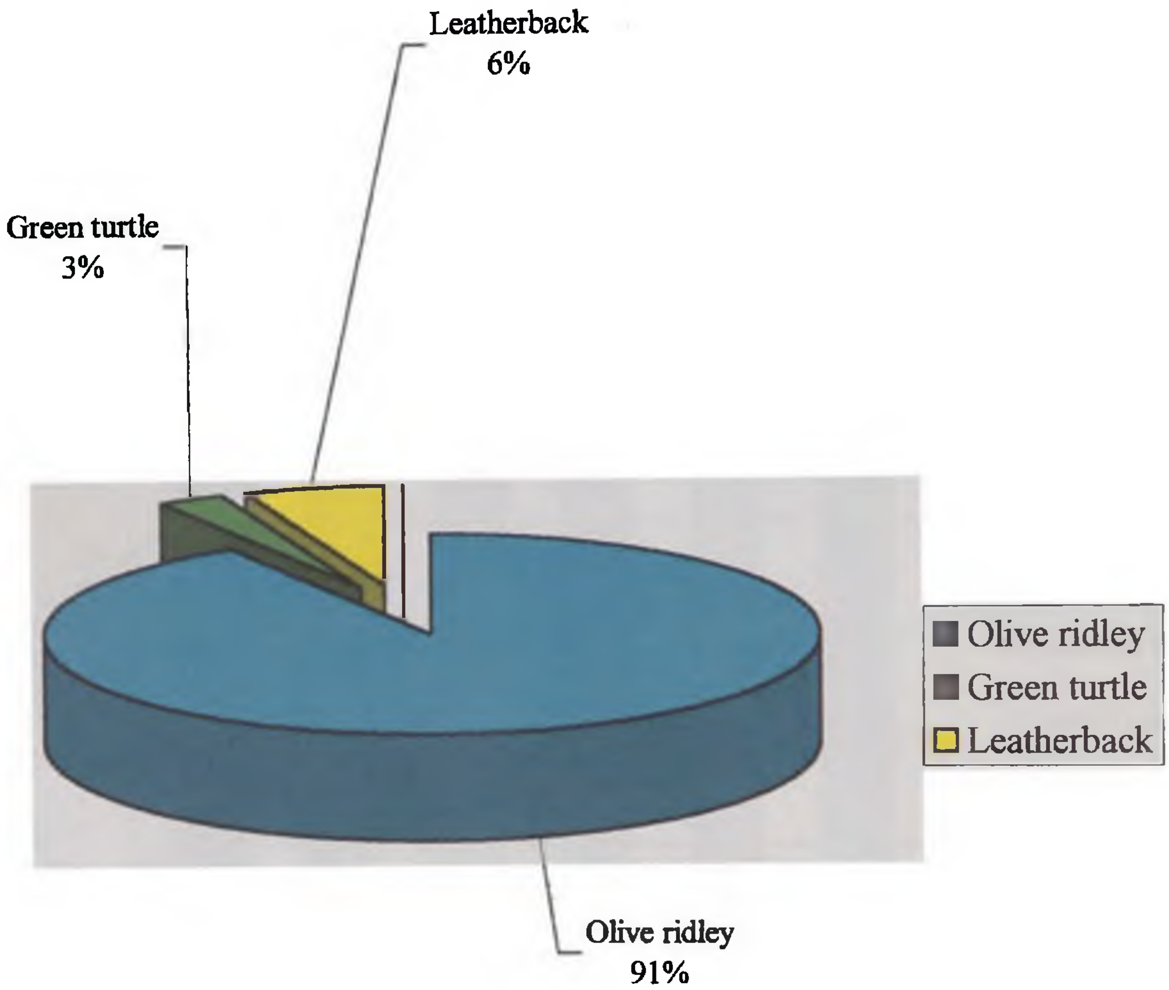

Figure 8. Relative occurrence of each nesting species in the intensive study area

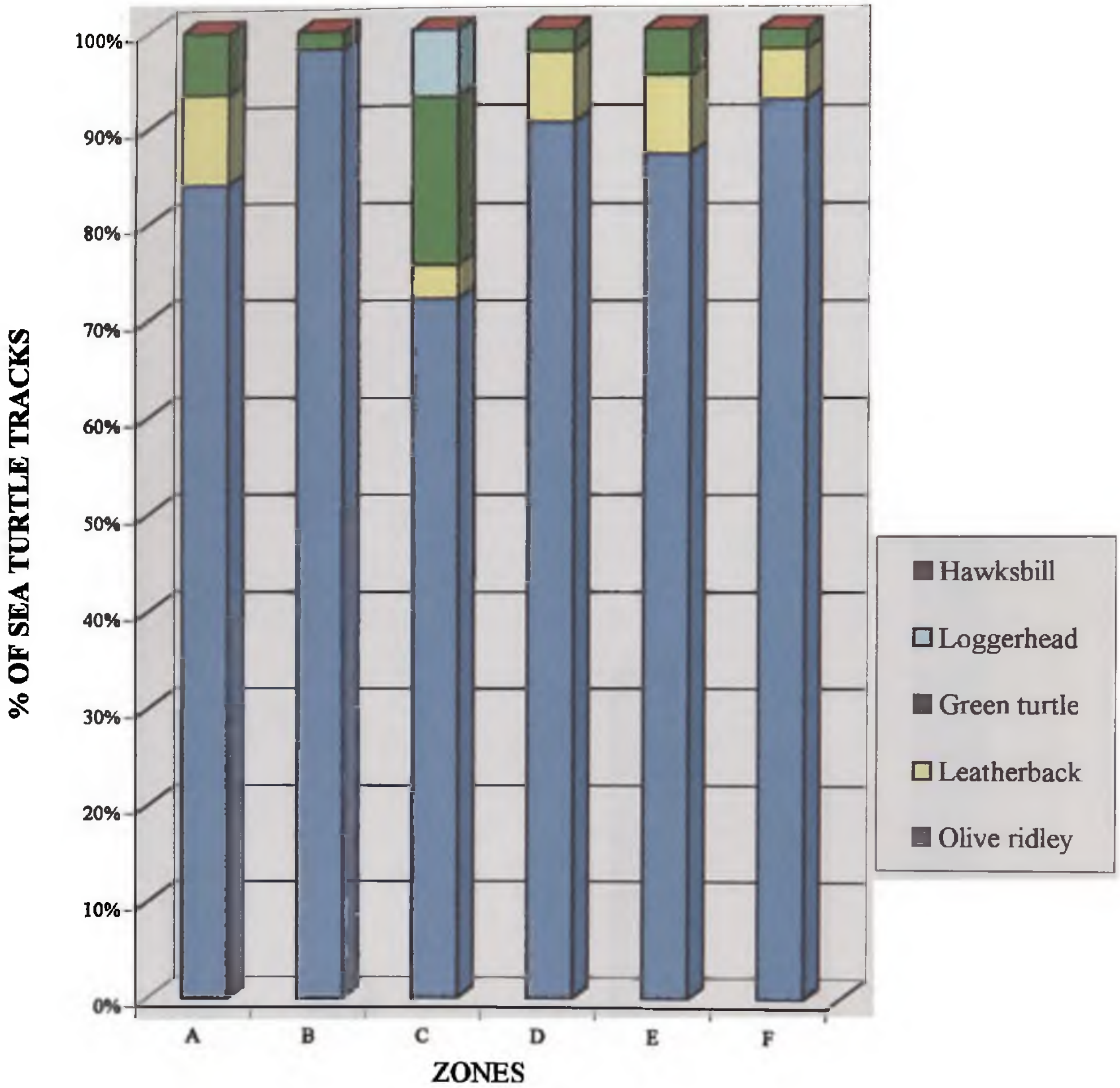

Figure 9. Relative percentage of each nesting species in each zone of the intensive study area

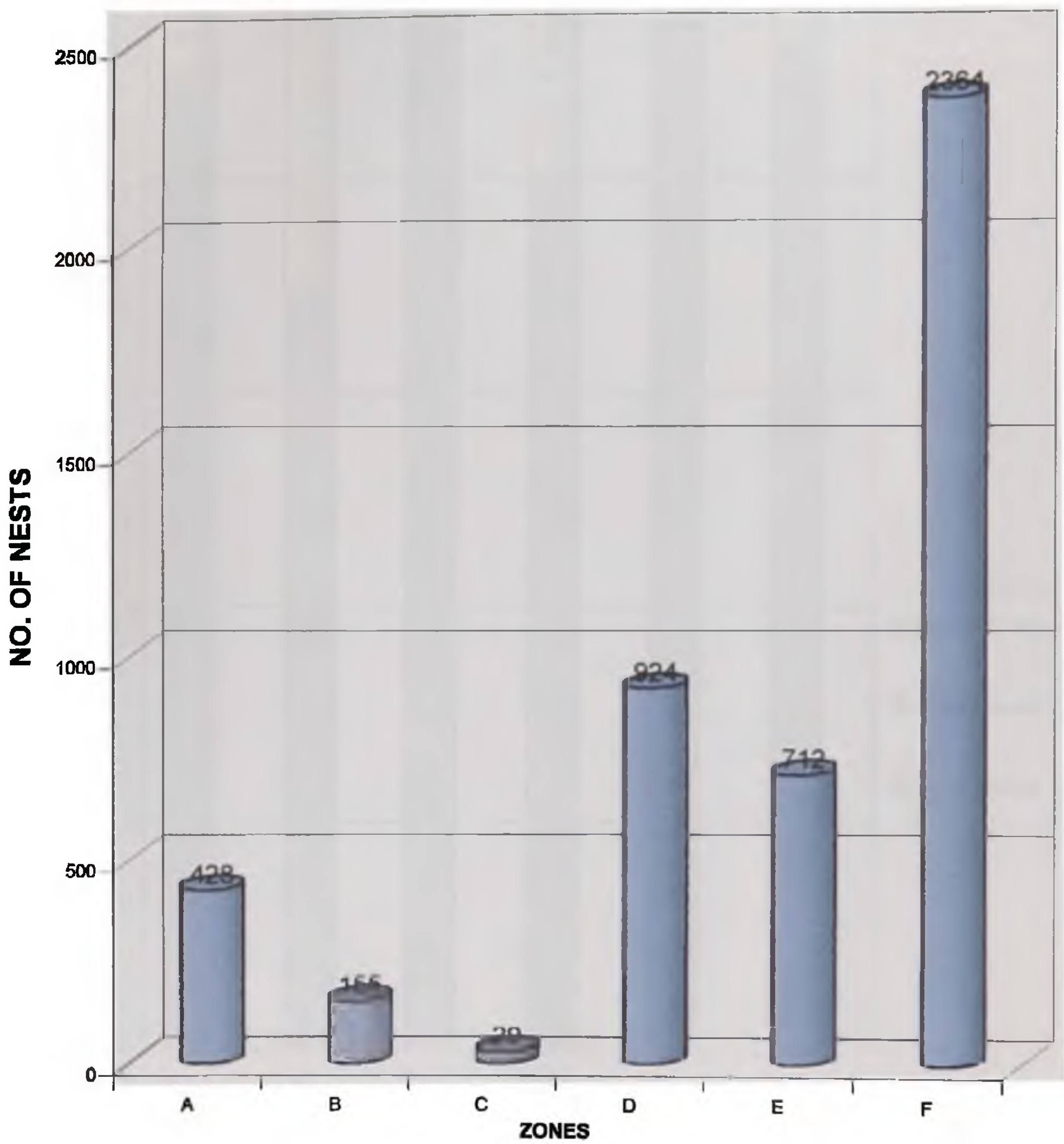

Figure 10. Total number of nests recorded in each zone during the study period

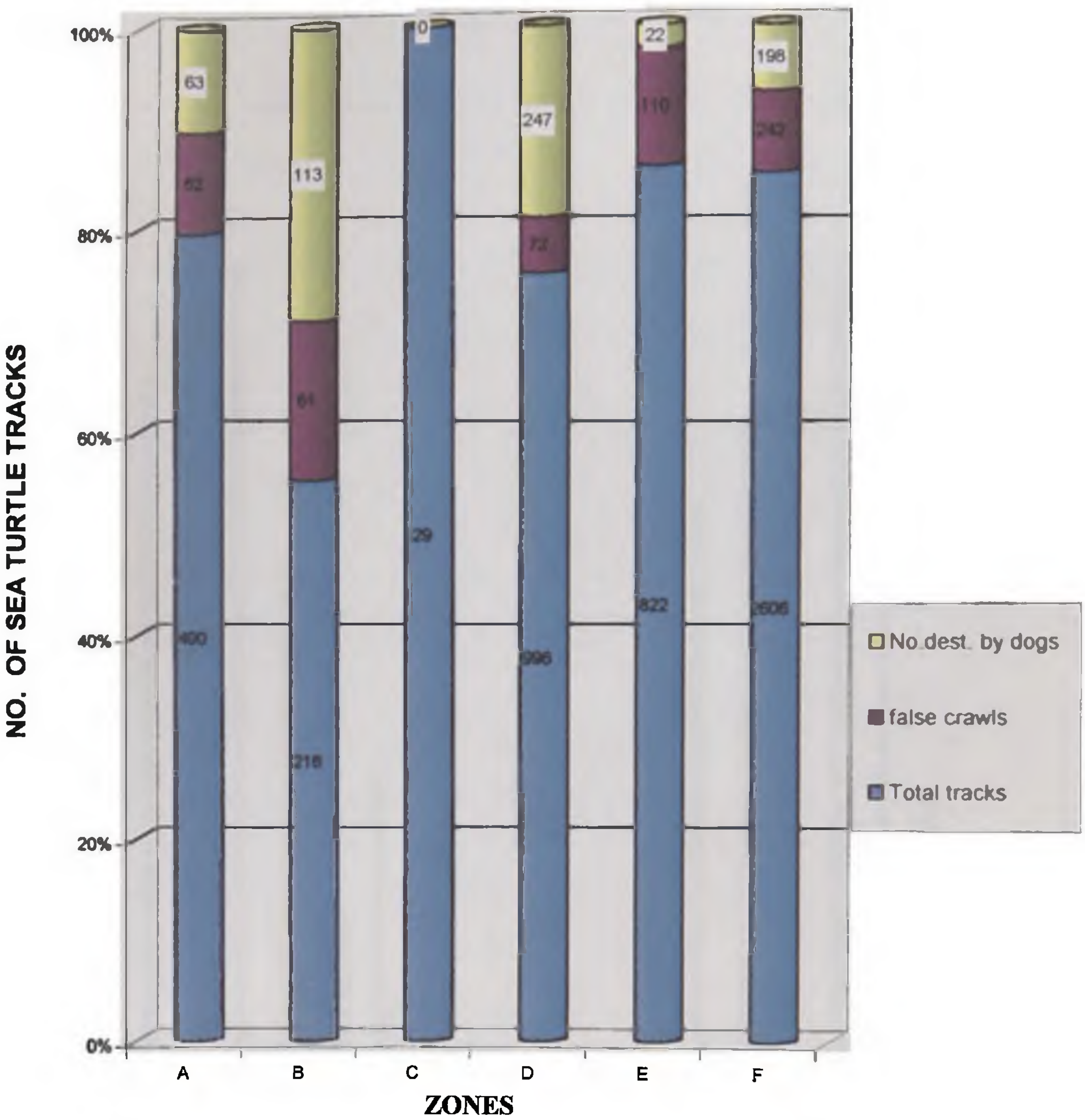

Figure 11. Percentage false crawls and nests destroyed by dogs in each zone

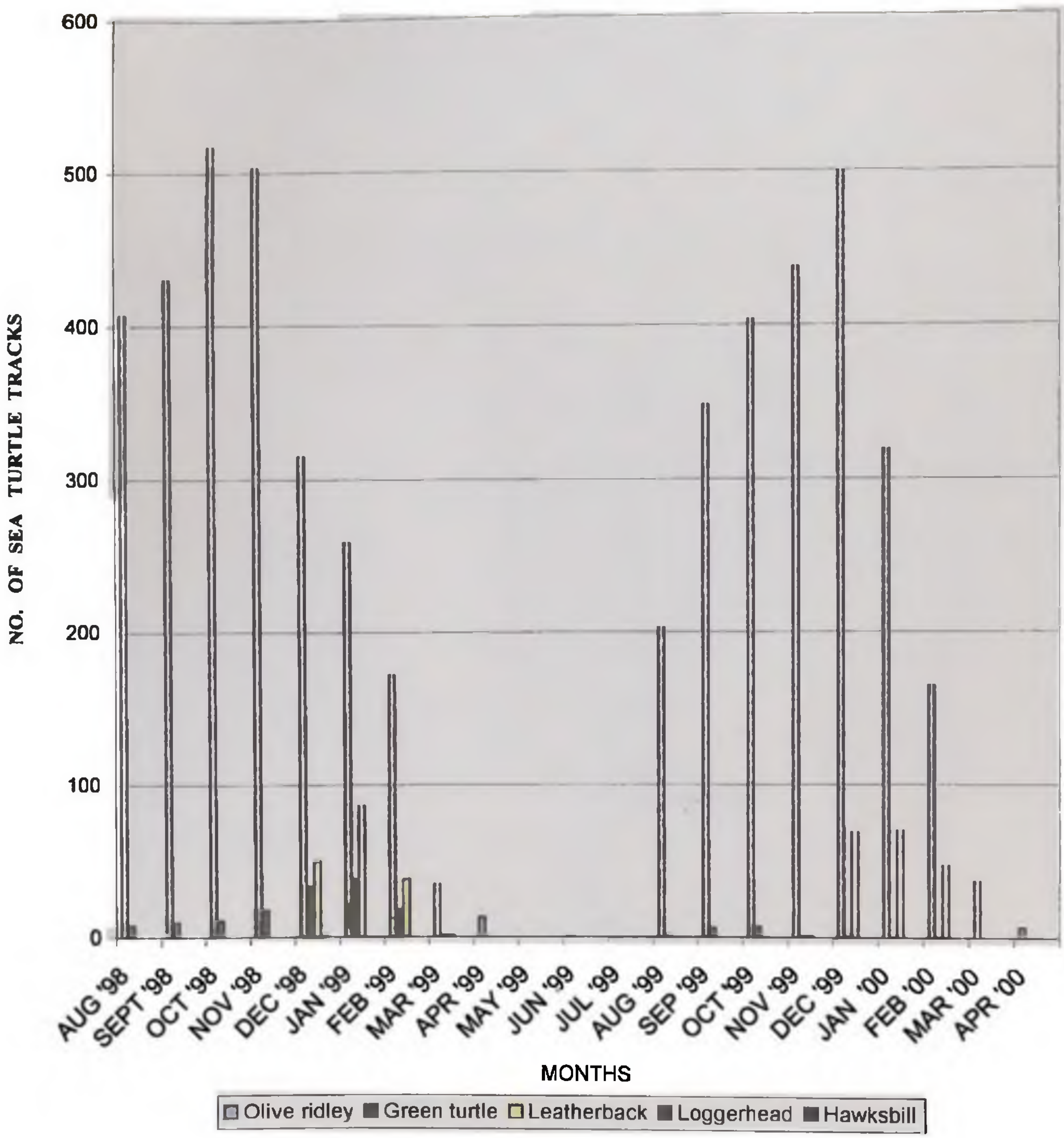

Figure 12 Sea turtle nesting activity at intensive study area

(Tables 3, 4 and 5). Also, percentage-hatching success was higher in Olive ridley 92.40 (SD=4.56) than Green turtle 89.38 (SD=6.64) and Leatherback 88.32 SD=2.70) as shown in tables 3, 4 and 5.

Table 2a. Data on nesting activities in Zone A

	Olive ridley	Green turtle	Leatherback	Loggerhead	Hawksbill	Total	False crawl	% False crawl	Dest. By dogs	% Dest.by Dogs
AUG '98	32	2	0	0	0	34	8	23.53	12	35.29
SEPT '98	38	2	0	0	0	40	5	12.50	9	22.50
OCT '98	54	2	0	0	0	56	9	16.07	5	8.93
NOV '98	60	4	0	0	0	64	12	18.75	5	7.81
DEC '98	35	12	4	0	0	51	4	7.84	2	3.92
JAN '99	32	6	16	0	0	54	3	5.56	8	14.81
FEB '99	8	2	6	0	0	16	1	6.25	4	25.00
MAR '99	2	0	0	0	0	2	0	0.00	0	0.00
APR '99	1	0	0	0	0	1	0	0.00	0	0.00
MAY '99	0	0	0	0	0	0	0	0.00	0	0.00
JUN '99	0	0	0	0	0	0	0	0.00	0	0.00
JUL '99	0	0	0	0	0	0	0	0.00	0	0.00
AUG '99	22	0	0	0	0	22	0	0.00	0	0.00
SEP'99	25	1	0	0	0	26	6	23.08	2	7.69
OCT '99	29	1	0	0	0	30	9	30.00	6	20.00
NOV '99	31	0	0	0	0	31	3	9.68	3	9.68
DEC '99	23	0	12	0	0	35	1	2.86	5	14.29
JAN '00	20	0	8	0	0	28	1	3.57	2	7.14
FEB '00	6	0	7	0	0	13	0	0.00	0	0.00
MAR '00	3	0	0	0	0	3	0	0.00	0	0.00
APR '00	0	0	0	0	0	0	0	0.00	0	0.00
Total	**412**	**32**	**46**	**0**	**0**	**490**	**62**	**12.65**	**63**	**12.86**

Table 2b. Data on nesting activities in Zone B

	Olive ridley	Green turtle	Leatherback	Loggerhead	Hawksbill	Total	False crawl	% False crawl	Dest. By dogs	% Dest.by Dogs
AUG '98	15	1	0	0	0	16	3	18.75	8	50
SEPT '98	18	1	0	0	0	19	5	26.32	10	52.63
OCT '98	21	0	0	0	0	21	8	38.10	8	38.10
NOV '98	33	2	0	0	0	35	15	42.86	18	51.43
DEC '98	29	0	0	0	0	29	10	34.48	13	44.83
JAN '99	17	0	0	0	0	17	8	47.06	10	58.82
FEB '99	4	0	0	0	0	4	0	0.00	1	25.00
MAR '99	0	0	0	0	0	0	0	0.00	0	0.00
APR '99	0	0	0	0	0	0	0	0.00	0	0.00
MAY '99	0	0	0	0	0	0	0	0.00	0	0.00
JUN '99	0	0	0	0	0	0	0	0.00	0	0.00
JUL '99	0	0	0	0	0	0	0	0.00	0	0.00
AUG '99	13	0	0	0	0	13	5	38.46	3	23.08
SEP'99	12	0	0	0	0	12	2	16.67	4	33.33
OCT '99	12	0	0	0	0	12	0	0.00	7	58.33
NOV '99	16	0	0	0	0	16	2	12.50	10	62.50
DEC '99	12	0	0	0	0	12	2	16.67	7	58.33
JAN '00	10	0	0	0	0	10	1	10.00	4	40.00
FEB '00	5	0	0	0	0	5	1	20.00	2	40.00
MAR '00	1	0	0	0	0	1	0	0.00	0	0.00
APR '00	0	0	0	0	0	0	0	0.00	0	0.00
Total	**212**	**4**	**0**	**0**	**0**	**216**	**61**	**28.24**	**103**	**47.69**

Table 2c. Data on nesting activities in Zone C

	Olive ridley	Green turtle	Leatherback	Loggerhead	Hawksbill	Total	False crawl	% False crawl	Dest. By dogs	% Dest.by Dogs
AUG '98	1	0	0	0	0	1	0	0	0	0
SEPT '98	1	0	0	0	0	1	0	0	0	0
OCT '98	2	0	0	0	0	2	0	0	0	0
NOV '98	1	0	0	0	0	1	0	0	0	0
DEC '98	0	0	0	2	0	2	0	0	0	0
JAN '99	4	5	1	0	0	10	0	0	0	0
FEB '99	0	0	0	0	0	0	0	0	0	0
MAR '99	0	0	0	0	0	0	0	0	0	0
APR '99	0	0	0	0	0	0	0	0	0	0
MAY '99	0	0	0	0	0	0	0	0	0	0
JUN '99	0	0	0	0	0	0	0	0	0	0
JUL '99	0	0	0	0	0	0	0	0	0	0
AUG '99	2	0	0	0	0	2	0	0	0	0
SEP'99	3	0	0	0	0	3	0	0	0	0
OCT '99	4	0	0	0	0	4	0	0	0	0
NOV '99	2	0	0	0	0	2	0	0	0	0
DEC '99	1	0	0	0	0	1	0	0	0	0
JAN '00	0	0	0	0	0	0	0	0	0	0
FEB '00	0	0	0	0	0	0	0	0	0	0
MAR '00	0	0	0	0	0	0	0	0	0	0
APR '00	0	0	0	0	0	0	0	0	0	0
Total	**21**	**5**	**1**	**2**	**0**	**29**	**0**	**0**	**0**	**0**

Table 2d. Data on nesting activities in Zone D

	Olive ridley	Green turtle	Leatherback	Loggerhead	Hawksbill	Total	False crawl	% False crawl	Dest. By dogs	% Dest.by Dogs
AUG '98	46	2	0	0	0	48	9	18.75	10	20.83
SEPT '98	63	2	0	0	0	65	12	18.46	18	27.69
OCT '98	85	2	0	0	0	87	8	9.20	20	22.99
NOV '98	78	3	0	0	0	81	12	14.81	16	19.75
DEC '98	72	5	16	0	0	93	7	7.53	33	35.48
JAN '99	67	5	20	0	0	92	10	10.87	27	29.35
FEB '99	62	1	9	0	0	72	3	4.17	18	25.00
MAR '99	26	0	0	0	0	26	0	0.00	8	30.77
APR '99	10	0	0	0	0	10	0	0.00	1	10.00
MAY '99	0	0	0	0	0	0	0	0.00	0	0.00
JUN '99	0	0	0	0	0	0	0	0.00	0	0.00
JUL '99	0	0	0	0	0	0	0	0.00	0	0.00
AUG '99	40	0	0	0	0	40	5	12.50	8	20.00
SEP'99	54	1	0	0	0	55	2	3.64	12	21.82
OCT '99	80	2	0	0	0	82	4	4.88	12	14.63
NOV '99	86	0	1	0	0	87	16	18.39	19	21.84
DEC '99	80	0	16	0	0	96	10	10.42	24	25.00
JAN '00	52	0	10	0	0	62	6	9.68	21	33.87
FEB '90	49	0	11	0	0	60	4	6.67	19	31.67
MAR '00	21	0	0	0	0	21	2	9.52	8	38.10
APR '00	3	0	0	0	0	3	0	0.00	0	0.00
Total	**901**	**23**	**72**	**0**	**0**	**996**	**72**	**7.23**	**247**	**24.80**

Table 2e. Data on nesting activities in Zone E

	Olive ridley	Green turtle	Leatherback	Loggerhead	Hawksbill	Total	False crawl	% False crawl	Dest. By dogs	% Dest.by Dogs
AUG '98	28	1	0	0	0	29	6	20.69	0	0
SEPT '98	56	1	0	0	0	57	4	7.02	1	1.75
OCT '98	88	3	0	0	0	91	10	10.99	2	2.20
NOV '98	78	5	0	0	0	83	18	21.69	2	2.41
DEC '98	73	8	14	0	0	95	13	13.68	6	6.32
JAN '99	63	10	17	0	0	90	9	10.00	2	2.22
FEB '99	46	6	5	0	0	57	3	5.26	1	1.75
MAR '99	3	0	0	0	0	3	0	0.00	0	0.00
APR '99	0	0	0	0	0	0	0	0.00	0	0.00
MAY '99	0	0	0	0	0	0	0	0.00	0	0.00
JUN '99	0	0	0	0	0	0	0	0.00	0	0.00
JUL '99	0	0	0	0	0	0	1	0.00	0	0.00
AUG '99	26	0	0	0	0	26	3	11.54	2	7.69
SEP'99	41	2	0	0	0	43	8	18.60	4	9.30
OCT '99	69	2	0	0	0	71	15	21.13	2	2.82
NOV '99	71	1	0	0	0	72	10	13.89	4	5.56
DEC '99	54	0	12	0	0	66	7	10.61	5	7.58
JAN '00	21	0	18	0	0	39	3	7.69	1	2.56
FEB '00	60	1	9	0	0	70	13	18.57	1	1.43
MAR '00	6	0	0	0	0	6	0	0.00	0	0.00
APR '00	0	0	0	0	0	0	0	0.00	0	0.00
Total	**717**	**39**	**66**	**0**	**0**	**822**	**110**	**13.38**	**22**	**2.68**

Table 2f. Data on nesting activities in Zone F

	Olive ridley	Green turtle	Leatherback	Loggerhead	Hawksbill	Total	False crawl	% False crawl	Dest. By dogs	% Dest.by Dogs
AUG '98	105	2	0	0	0	107	31	28.97	34	31.78
SEPT '98	254	4	0	0	0	258	53	20.54	10	3.88
OCT '98	267	4	0	0	0	271	30	11.07	8	2.95
NOV '98	253	4	0	0	0	257	21	8.17	8	3.11
DEC '98	106	8	16	0	0	130	18	13.85	12	9.23
JAN '99	76	12	32	0	0	120	13	10.83	10	8.33
FEB '99	52	9	18	0	0	79	7	8.86	14	17.72
MAR '99	4	2	1	0	0	7	1	14.29	3	42.86
APR '99	2	0	0	0	0	2	0	0.00	2	100.00
MAY '99	0	0	0	0	0	0	0	0.00	0	0.00
JUN '99	1	0	0	0	0	1	0	0.00	0	0.00
JUL '99	0	0	0	0	0	0	0	0.00	0	0.00
AUG '99	100	2	0	0	0	102	22	21.57	21	20.59
SEP'99	213	2	0	0	0	215	20	9.30	33	15.35
OCT '99	209	2	4	0	0	215	26	12.09	43	20.00
NOV '99	231	0	0	0	0	231	20	8.66	45	19.48
DEC '99	329	2	29	0	0	360	19	5.28	47	13.06
JAN '00	216	1	34	0	0	251	18	7.17	34	13.55
FEB '00	45	0	20	0	0	65	13	20.00	19	29.23
MAR '00	6	0	0	0	0	6	0	0.00	1	16.67
APR '00	4	0	0	0	0	4	0	0.00	0	0.00
Total	**2418**	**54**	**134**	**0**	**0**	**2606**	**242**	**9.29**	**198**	**7.60**

Table 3 Emergence period and hatching success of olive ridley

Wt. of 1 eggshell= 0.9578g

Nest code	Emergence period (days)	Total wt (g).	Hatched eggs	unhatched eggs	Total eggs laid	% Hatching success
14	53	56.5341	59	-	-	-
2	51	69.9394	73	-	-	-
7	50	68.9724	72	5	77	93.51
35	54	65.1304	68	4	72	94.44
32	56	60.3423	63	-	-	-
30A	51	75.6654	79	-	-	-
48A	49	71.816	75	7	82	91.46
88A	52	71.8346	75	15	90	83.33
104A	53	63.425	66	6	72	91.69
102A	50	74.7091	78	6	84	92.86
114A	56	54.5845	57	8	65	87.69
95A	54	75.6561	79	12	91	86.81
97A	51	75.547	79	8	87	90.79
107A	51	88.1177	92	6	98	93.88
105A	53	89.0753	93	8	101	92.08
110A	49	82.3707	86	0	86	100.00
113A	52	93.8642	98	0	98	100.00
112A	54	92.9066	97	5	102	95.10
Mean	**52.**		**77**	**6**	**86**	**92.40**
SD	**2.12**		**12**	**3.98**	**12**	**4.56**

(-) = Nest was not marked / pegs were lost

Table 4 Emergence period and hatching success of Green turtle

Wt. Of 1 eggshell = 1.01 g

Nest code	Emergence period (days)	Total wt. (g)	Hatched eggs	unhatched eggs	Total eggs laid	%Hatching success
24	54	70.71	70	6	76	92.11
21	56	83.832	83	0	83	100.00
36A	55	88.882	88	10	98	89.80
65A	58	62.566	62	11	73	84.92
58A	50	76.757	76	24	100	76.00
59A	57	96.96	96	2	98	97.96
126A	57	71.713	71	12	83	85.54
116A	56	73.732	73	9	82	89.02
121A	58	61.598	61	4	65	93.85
108A	60	64.642	64	5	69	92.75
85A	58	72.705	72	15	87	82.76
44A	58	72.721	72	10	82	87.81
Mean	**56.4**		**74**	**9**	**83**	**89.38**
SD	**2.57**		**11**	**6.4**	**11**	**6.64**

Table 5 Emergence period and hatching success of Leatherback

Wt. Of 1 eggshell = 2.1g

Nest code	Emergence period (days)	Total wt.	Hatched eggs	unhatched eggs	Total eggs laid	% Hatching success
		172.551	82		-	
-		106.948	51		-	
1	57	199.945	95	12	107	88.81
-	-	128.203	61		-	
		178.534	85	-	-	-
13	60	195.311	93	12	105	88.57
29	60	165.901	79	11	90	87.78
124A	66	189	90	10	100	90.00
104B	66	178.534	85			
	65	151.21	72	7	79	91.14
89A	62	130.206	62	6	68	91.18
84A	62	113.418	54	11	65	83.08
90A	69	119.7	57	10	67	85.07
103	60	123.306	59	6	65	90.73
83A	63	111.306	53	8	61	86.89
Mean	**62.7**		**72**	**9.3**	**81**	**88.32**
SD	**3.50**		**16**	**2.36**	**18**	**2.70**

5.3.3 BIOMETRIC MEASUREMENTS

During the 1999/2000 nesting season, sixteen Olive ridleys and twelve Leatherbacks were observed (Plates 5-11) and measured.

Table 6 shows biometric measurements for the Olive ridley and the Leatherback. The mean minimum curved carapace length (CCLmin) and maximum curved carapace width (CCWmax) were 69.0cm (SD=3.36) and 68.1cm (SD=2.21) respectively. For the Leatherback, CCLmin was 154.3 (SD=5.50) and CCWmax was 110.0cm (SD=5.14). The mean track width and nest depth were measured as 66.2cm (SD=8.11) and 34.4cm (SD=0.98) respectively. The mean number of eggs laid was 100 (SD=6.64). Corresponding values for Leatherback, were CCLmin =154.3cm (n=12, SD=5.50) and CCWmax = 110.0 (SD=5.14); track width =157.3 (SD=16.73); nest depth=65.3 (SD=3.20). Mean number of yolked eggs laid was 85 (SD=10).

Estimated and observed clutch sizes for Leatherbacks based on 9 and 12 nests respectively are shown in table 7. Corresponding values for the Olive ridley was based on 14 and 16 nests. H_o = There is no difference between the means of clutch size estimated for each species and that actually counted.

The calculated t value is less than the tabulated t value for both the Olive ridley and Leatherback turtles. We therefore accept the Null hypothesis (H_o) in both cases and conclude that there is no statistically significant difference between the means for each species. Thus, one can gather the empty eggshells from sea turtle nest, dry, weigh and have a reliable estimate of the clutch size.

Plate 5 Leatherback turtle returning to sea after nesting on the beach at Ada

Plate 6 Olive ridley turtle nesting at zone F (Old Ningo)

Plate 7 Measuring curved carapace length (CCLmin) of an Olive ridley turtle at zone F (Old Ningo).

Plate 8 Eggs of Leatherback turtle during nesting at zone F (Old Ningo)

Plate 9 Olive ridley laying eggs at zone F (Old Ningo)

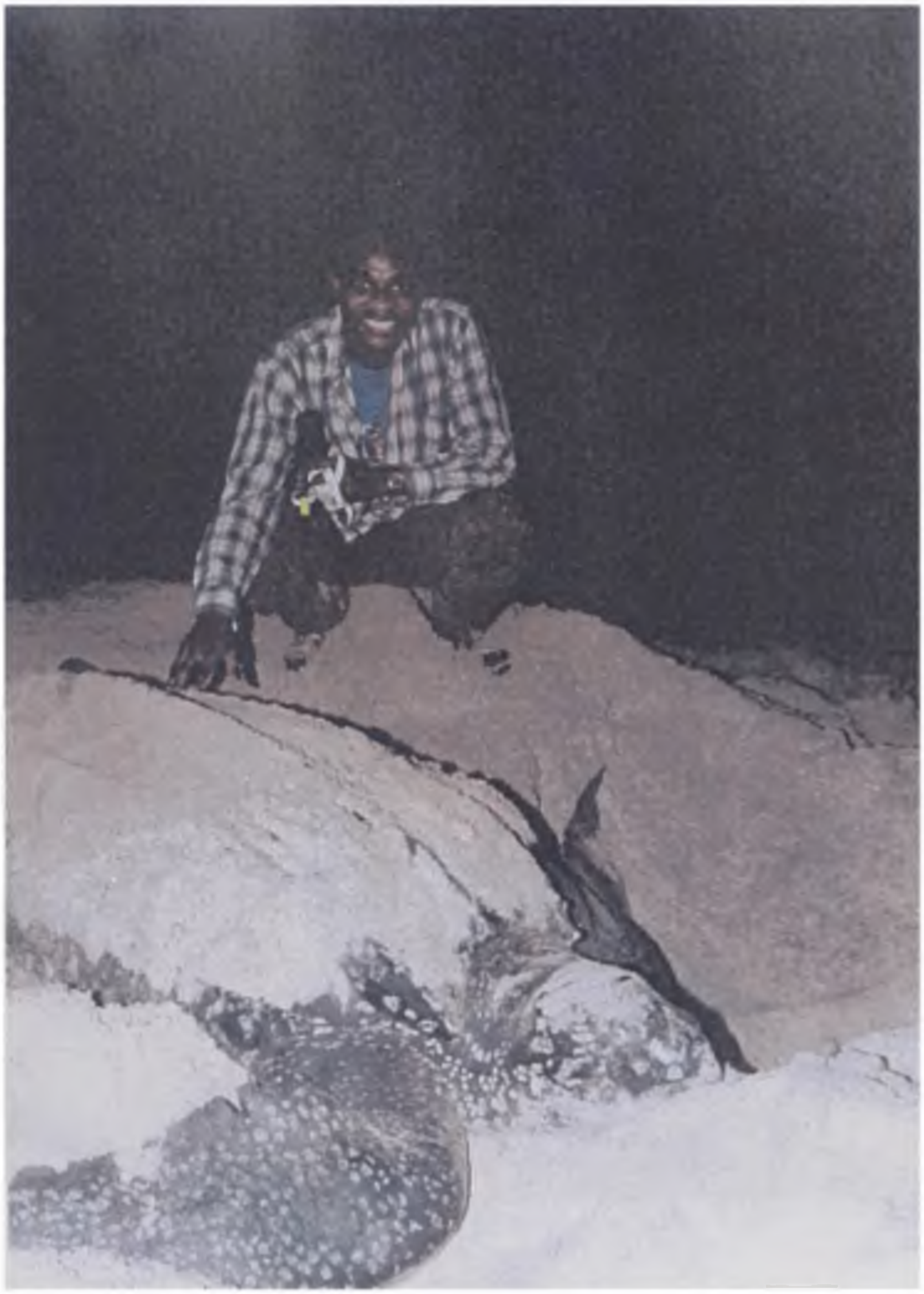

Plate 10 Leatherback turtle 'camouflaging' after nesting at Ada

Plate 11 One of several carapace of Leatherback turtles found on the beach at Anloga

Table 6 Biometric measurements for Olive ridley and Leatherback turtles

OLIVE RIDLEY

	CCLmin(cm)	CCWmax(cm)	Track width(cm)	Nest depth	No. of eggs
	67.3	66.5	63.5	33.5	98
	70	70	45.7	33	95
	69	69	74	34	89
	63	67.8	60.9	36	105
	67	66	61	34.5	95
	73.4	71.7	73.6	35	113
	72.2	69.5	76.2	34.5	103
	68.6	66	63.5	34	100
	68.6	66	68.6	36	102
	68.6	66	71.1	33	93
	68.6	66	68.6	34	104
	75	71.5	76.3	34.5	102
	63	67	60.5	33.5	92
	69	69	74	34.3	90
	67.3	66.1	61.3	33.8	104
	73.5	71.5	61	36	106
Mean	69.0	68.1	66.2	34.4	100
SD	3.36	2.21	8.11	0.98	6.64

LEATHERBACK

	CCLmin(cm)	CCWmax(cm)	Track width(cm)	Nest depth	No. of eggs
	150.2	112	168	65	70
	158	112.2	167.6	68	73
	155	109	154.9	60.6	69
	146	97	167.6	64.5	80
	156.1	116.8	166.8	69.5	101
	164	112	170	67	90
	157	111.9	167.6	60.5	94
	151	108.8	165.1	68	86
	161.2	114	138	69.8	90
	146	104	130	65.1	86
	153.1	110.7	124	63.6	95
	154.3	112	167.4	62.4	81
Mean	154.3	110.0	157.3	65.3	85
SD	5.50	5.14	16.73	3.20	10

Table 7 T-test on novel method used in estimating clutch size

LEATHERBACK		OLIVE RIDLEY	
ESTIMATED	OBSERVED	ESTIMATED	OBSERVED
107	70	77	98
105	73	72	95
100	69	82	89
79	80	90	105
68	101	72	95
65	90	84	113
67	94	65	103
65	86	91	100
61	90	87	102
	86	98	93
	95	101	104
	81	86	102
		98	92
		102	90
			104
			106
MEAN 80.70	84.58	86.07	98.65
SD 18.18	10.24	11.59	6.64

P= 0.05 p=0.05

df=20 df=25

t-test = 0.558 t-test = 0.001

t – tabulated = 2.086 t - tabulated = 2.06

5.4.0 DISCUSSION

The nesting season for Olive ridley spans from early August to early March. It appears that this species would have nested throughout the year but for the major rains that set in from mid-April. Ghana experiences two maximal annual rainfall distribution, the major occurring in May-June and the minor in September-October. Presumably, sea turtles may be avoiding the heavy rains during May-July to protect their eggs and make use of the dry season which is conducive for the development of their eggs. Surprisingly, one Olive ridley track was recorded in early June of 1999. This turtle did lay. It might probably be one of the late nesters that did not finish laying all its clutches before the end of the 1998/99 nesting season.

Olive ridleys are known to migrate along continental shelves, feeding in shallow waters and converging in summer and autumn for nesting on beaches of slight slope with fine and medium to coarse-grained sand (Márquez, 1990). The beach along Prampram, New Ningo and Old Ningo form perfect nesting sites for this species in terms of the beach slope and mean particle grain size between 0.25 to 0.36, (medium to coarse sand) on the phi scale.

The Green turtle and Leatherback nest mainly from November to February, perhaps to avoid the two raining seasons and also to make use of the higher temperatures around January, February and March. Nesting activities of the three species overlap in December, January and February. However, there appears to be temporal separation in nesting of species evidenced by non-overlap in peak months for Olive ridley and leatherback turtles. Very few Green turtles nested during the 1999/2000 nesting season as compared to the previous season. The reason might be the usually two year breeding cycle exhibited by most Green turtles around the world. They may also breed in cycles of one, 3 or 4 years. Some switch from one to another cycle as a result of ageing or external influences such as food quality and quantity. Successive seasonal nesting migrations is also said to depend on the population, feeding ground quality and remoteness. A survey conducted along the entire coast showed that fewer Green turtles nest along the Ghana shoreline.

The two Loggerhead tracks observed in December, 1998 was surprising. Those were the only loggerhead tracks observed throughout the entire study period. Earlier survey report by Toth and Toth (1974) included the identification of this species from shells found on the shore. Márquez (1990) believed that this species may nest in the Gulf of Guinea although there has not yet been any report. Although remote, it is possible that these loggerheads might have strayed from either Morocco, Cape Verde Archipelago or Dakar (Senegal) where minor nesting of loggerheads is known.

Sometimes nesting females crawl out of the ocean, but for unknown reasons decide not to nest. This is described by turtle researchers as ‘false crawl’. It can happen naturally or be caused by artificial lighting or one’s presence on the beach. The percentages of false crawls by the nesting turtles were high in some zones. For instance zones B and F where 31.46% and 14.49% of the total tracks were false crawls. The cause may be attributed to some form of disturbances most likely the presence of dogs, lighting, or human presence. Signs of abandoned partially constructed nest were, however, not observed. Percentage nests destroyed by dogs in some zones were very high. At zone B, as much as 47.69% of the total freshly laid clutches were destroyed by dogs. This zone is very close to the human habitation at

Lower Prampram. One of the community's refuse dump is also located within this zone. Some members of the community defaecate at this area.

The average emergence period of 52 days (range 49.9-54) obtained for the Olive ridley is not quite different from that obtained from other areas. For example, in Escobilla, Mexico it ranges between 47 to 58 days, in Surinam 49 to 62 days, in Australia 48 to 51 days and in India 50 to 62 days (Márquez, 1990). Since incubation period of sea turtle eggs correlates strongly with temperature and humidity as well as other parameters such as sand grain size, organic matter content, clutch size, date of oviposition and also the proximity to other nests, the emergence period may change spatially and/ or temporally. Fifty-six days (range 54-59) and 63 days (range 60-67) were obtained for Green turtles and leatherbacks respectively. This is in line with 48 to 70 days for Green turtles and 50 to 70 days for Leatherbacks documented by Márquez (1990).

Estimated average clutch sizes, based on total weights of hatched eggs, for Olive ridley, Green and Leatherback were 86 (74-98), 83 (72-94) and 81(63-99) respectively. The means of these clutch size estimates compared to the means of observed clutch sizes in the case of the Olive ridley and the Leatherback showed no statistically significant difference (Table 7). This implies that determination of clutch size of these species can easily be obtained by gathering empty eggshells from excavated nests, dry, weigh and divide the total weight by the weight of a single eggshell. This saves one from the ordeal of going to the nesting beach at night to count the eggs as they are laid by the turtles in order to determine the clutch size.

Hatching success for the three species was very high. The Olive ridley recorded 92.40% (range 87.84-96.96); Green turtle 89.38% (range 76.00-100.00), and leatherback 88.32% (range 85.62- 91.02). These figures are very encouraging and may have been the result of optimum conditions prevailing at the nesting beach. These may include the combination of abiotic and biotic factors. The abiotic factors such as low levels of silt/clay, low salinity, low levels of organic carbon; moderate sorting, mean particle diameters ranging from 0.2 to 1.0mm and high sphericity as described by Mortimer (1988). These abiotic factors, with the exception of sphericity which was not measured, prevail in the study area. Biotic factors such as number of yolked and yolkless eggs are also important in determining hatching success. Hall (1982) found that the percentage yolkless eggs correlated highly positively with hatching success in her study at Culebra Island, Puerto Rico. Unfortunately, the number of yolkless eggs laid by the sea turtles were not investigated in this study due to time constraints and so may need to be investigated in future studies.

At zone C, though there was less nesting activity, because of its distance from the communities there was virtually no destruction by dogs. Zone D which is along New Ningo, recorded 24.8% destruction by the dogs. At zone E, the story was different in that the dogs there are owned by owners of the holiday chalets, and are under some form of supervision by the caretakers, hence are not allowed to loiter at the beach. That might have accounted for the low level of nest destruction by the dogs in that area. At zone F, 7.0% of the freshly laid clutches were destroyed, however, with old nests inclusive, the figure could be as high as 40% of the total nests being destroyed by dogs. Most of these nests were located within the first 1½ km portion of this zone which is closer to the Old Ningo township and is easily accessible by the dogs.

A number of measurements of sea turtles are taken for various reasons. For instance, they are measured on nesting beaches in order to relate body size to reproductive output, to determine minimum size at sexual maturity, and to monitor nesting female size for a particular rookery. They may also be measured on foraging grounds to determine growth rates. According to Bolten (1999), the size frequency of a population is an important parameter of that population's demographic structure. Analyses of the growth rates also can indicate habitat quality and physiological status.

Although linear measurements can also be taken with callipers instead of the flexible tape measure which is less expensive, more convenient to carry and maintained, curved measures are said to be less accurate and less precise (Bjorndal and Bolten, 1999; Shoop and Ruckdeschel, 1986); in that, some irregularities and epibionts occur on the surface of the turtle's shell. Juveniles of some species have keeled vertebrals, the posterior carapace in some species has a steep change in slope and this makes carapace length difficult to measure with accuracy and precision.

CHAPTER SIX

GENERAL DISCUSSION

Sea turtles are known to nest along the shores of Ghana. Unfortunately, no detailed studies notably on reproductive aspects have been conducted and published on them for the purposes of their management and protection. They are hunted in their numbers by coastal communities for their meat and eggs as well as their oil which is believed to have medicinal value. Results from this study have shown that sea turtle nesting activity occurs along the entire coast of Ghana, with the intensity of nesting increasing from west to east. The Olive ridley was found to be the most abundant species, followed by the Leatherback and the Green turtle. Surprisingly, most of the interviewees agreed that the Leatherback is very common on their beaches. This was confirmed by the presence of Leatherback carcasses on beaches at PrincessTown in the west and Anloga in the east. A few drowned Leatherback turtles were also found on beaches at Old Ningo and Ada. Leatherback nesting population in Ghana is definitely higher than previously envisaged. The Leatherback nesting population in Ghana could be speculated as being between 500-1000, and that for Olive ridley and Green turtle as between 2000-2500 and 800-1300 respectively. However, the use of short term survey records to evaluate the status of a population has been ill-advised because of the natural variability of inter-annual nesting numbers (Valverde and Gates, 1999).

Conspicuously absent during this study was the hawksbill turtle. A few fishermen (about 10.1 %) interviewed claim they have seen the hawksbill turtle at sea. This information is yet to be confirmed. This species is said to be the most tropical of all sea turtles and is distributed throughout the Central Atlantic and Indo-Pacific Regions. Some coastal communities still use sea turtles as one of their sources of meat. About 60% of fishermen interviewed said they still eat sea turtle meat. This was confirmed by the number of sea turtle carcasses that littered some of the beaches visited. On one occasion a huge leatherback was seen being dragged by fishermen for slaughter at Abandze in the Central Region. Only a few of the fishermen said they were aware that it is illegal to hunt sea turtles in Ghana. There is therefore the need for intensification of educational programmes aimed at creating the awareness on the need for protection and conservation of sea turtles in Ghana. Fishing communities between PrincessTown and Busua, Abandze; and Anloga should be included on the priority list. Law enforcement agencies must enforce L.I 685, which protects sea turtles in Ghana. Some communities have started prosecuting sea turtles poachers. At Anloga, during the 1999/2000 season, two fishermen were fined by a law court for hunting sea turtles, one could not pay and was put in jail. Such acts would deter other members of the community from hunting these endangered species.

The claim by fishermen at Prampram that no sea turtle had been landed on their beach for the past two years is encouraging if that is true. That means the fishermen are responding to the educational campaign undertaken by Resource and Environment Development Organisation (a local NGO) aimed at creating public awareness on the need to protect sea turtles.

The nesting season for sea turtles was found to start in August, reaching its peak in December and ending in March, sometimes in early April. This nesting duration coincides with that of Praia do Forte (Brazil) where nesting extends from late August till early April. The peak nesting occurs between mid-October and mid-December for the loggerhead, *Caretta caretta*, and between early January and late February for *E. imbricata* (Marcovaldi and Laurent, 1996). Results from the intensive study area showed that the highest nesting activity for Olive ridley occurred in October for the 1998/99 season but shifted to December in the 1999/2000 season. The number of nesting leatherbacks was highest in January for the 1998/99 season but in the 1999/2000 season it was highest in December and January. Relatively very few Green turtles nested during the 1999/2000 season compared to the previous nesting season. The inconsistency in the number of each species during the various nesting seasons may be attributed to the differences in nesting periodicity that occurs in sea turtles which might be related to their migratory behaviour. The herbivorous Green turtle is known to be the one that undertakes periodic long distance travel, mostly between circumscribed, racial breeding and feeding grounds. With the exception of few individuals of some sea turtles colonies which occasionally make return breeding migrations after one year absence, most migratory periods are two, three or four years. Some researchers have stated two (Carr and Ogren, 1960) three and four year cycles for the Green turtle colony in west Caribbean using data from Tortuguero (Costa Rica) and confirmed the predominance of three-year cycle there.

Some individuals are said to shift their inter-migratory periods from longer to shorter duration, or vice versa. Carr *et al.* (1982) pointed out that the two–year or three–year cycles may be caused by external ecological influences. The number of Green turtles nesting at the intensive study area could have been underestimated. Probably, due to preferences for other nearby nesting beaches. According to a wildlife volunteer at Old Ningo, most Green turtles nest at Akplabanya further east of the study area. Records on nesting activities of the Leatherback turtle in the eastern Atlantic Ocean are known. Solitary nesting has been recorded from Mauritania, Senegal, Liberia, Togo, Zaire and Angola as well as Ghana. The most important known breeding grounds are the western coast of Mexico where over 80,000 nests are recorded per year. Sporadic nesting occurs around Half Assini, increasing moderately on beaches between PrincessTown and Busua. A similar situation occurs after Takoradi, where nesting starts sporadically increasing moderately on beaches between Winneba and Accra. High nesting activities of all three species take place east of Accra, from Prampram to Denu. This finding agrees with that documented by Toth and Toth, (1974), Carr and Campbell (1995).

False crawls exhibited by sea turtles may be due to disturbances encountered on the nesting beach. Percentage false crawls recorded were higher in zones closer to human habitations. Lights from the buildings close to the beaches might contribute to higher percentages of false crawls in zones B and E (Figure 11). Some occupants of beach chalets at zone E confirmed having seen hatchlings move into their compounds and they sometimes have to carry them into the sea. Light sources from buildings closer to the nesting beaches can be minimized by repositioning them behind shielding objects so that light does not reach the beach. Interior lighting can be reduced by moving light sources away from windows. In Florida, communities near nesting beaches have light-management ordinances designed to protect sea turtles. This example could be emulated in Ghana.

Total number of sea turtle nests recorded in each zone indicated that Zones D and F provided excellent nesting habitat for nesting. It was clear that destruction of sea turtle eggs by dogs and pigs is not wide spread along the coast of Ghana. However, this problem was prevalent in the intensive study area (Figure 11). The total clutch destruction (both freshly laid and old) may be estimated to be about 40%. The situation is so alarming and has been one of the major worries of most fishermen at New and Old Ningo. They suggested that dogs found destroying turtle nests should be shot dead since members of their communities have already been advised to keep their dogs in chains to prevent them from straying to the beaches. At Akplabanya, with the assistance of one of the financial institutions in the country, the community has been provided with pig sties to keep pigs away from the beach. Ghost crabs were also observed destroying sea turtle eggs within the intensive study area. However, their activity was not evaluated.

Sediment analysis of sand samples obtained from various beaches along the entire coast showed that most of the beaches have grain sizes ranging between 0.1 and 0.4 mm and support moderate to high nesting activity. These grain sizes are similar to some important sea turtle nesting sites in other parts of the world such as Ascension Island. Beaches at Bortianor, Anloga and Denu, though have coarse sediments happen to serve as nesting sites for sea turtles. It therefore appears that leatherback and the Olive ridley nest in sands having a wide variety of textures. This is similar to observations made on the Green turtle by Mortimer (1982). The preferred grain size properties of nesting sea turtles in Ghana are median grain size of 0.2 - 0.4 mm (medium-coarse sand) and sorting coefficient 0.4 - 0.7 (well-sorted to moderately well sorted).

Emergence period for Olive ridley turtles is usually between 45 and 65 days (Márquez, 1990). In this study, mean number of 52 days (range 49.9–54) was estimated. This is comparable with values obtained from other nesting beaches such as Surinam (49 to 62), Mexico (47-58) and Australia 48-51. Estimated average clutch size based on hatched eggs for Olive ridley was 86 (74-98). However, observed average clutch size was 90 (89–106). Average clutch size for Olive ridley varies from locality to locality. For example, in Mexico, the average clutch size is 105.3 eggs, Honduras, 108.3 eggs and Costa Rica (Nancite) 105 eggs (Márquez, 1990).

For the Green turtles, average emergence period was 56 days (54-59). This value falls within the known incubation period of 48 to 70 days. However, the estimated average clutch size of 83 (72-94) is slightly lower than the average of 84.6 eggs (in the Solomon Islands) to 144.4 eggs (in South Africa) (Márquez, 1990).

The mean emergence period obtained for the Leatherback was 63 days. Mean emergence period recorded at Mexiquillo (Mexico) during the 1980-81 nesting season was 65.2 days. Other records include between 60.3 and 63.9 days in Saint Croix (Costa Rica) and mean of 57.6 days recorded in Puerto Rico (Márquez 1990). Estimated clutch size for the Leatherback was 81(63-99). This value excludes the yolkless eggs. Although the percentage of yolkless eggs was not determined in this study, there were variations in the sizes of the yolkless eggs. One Leatherback laid less than five normal eggs with several yolkless eggs. It could probably have been its last clutch for the season. Data on clutch size of the Leatherback from other nesting beaches include Michoacan (Mexico) 59.1; Costal Rica, Atlantic coast 46-128 normal eggs with mean of 81.6; Pacific coast from 53 to 79 normal eggs with mean of 65.5; Sri Lanka 90 to 130 and China 90 to 150 (Márquez, 1990).

T–test evaluation of a method for rapid clutch size estimation showed no statistical significant difference between the means of the estimated values and those actually counted. Therefore clutch size estimate could easily be obtained from the empty eggshells after a nest had hatched. Hence one would not necessarily have to visit the nesting beach at night to count eggs as they are laid for the purpose of clutch size determination.

Hatching success is affected by direct and indirect disturbance of the beach by man, storms, floods, erosion, dryness, sand compaction, fungus and bacterial invasion and predation. In this study the percentage hatching success was defined as a percentage of hatched number of eggs to the estimated clutch size. Percentage hatching success for Olive ridley, was 92.40 and highest among the three species. Percentage values of 89.38 and 88.32 were recorded for Green turtles and Leatherbacks respectively. The highest percentage hatching success obtained for the Olive ridley might be due to shallow nature of their nest, which was about 38cm deep. Generally, the high percentage hatching success for the three species is really encouraging. The environmental factors such as temperature, moisture and gaseous exchange might be optimal at the intensive study area.

The size of sea turtles is principally related to the carapace length, which is considered a reliable measure of overall size. The mean sizes of nesting females show wide variations from place to place. Mean minimum carapace length (CCLmin) measured for Olive ridley was 69.0cm (SD=3.36) and maximum curved carapace width was 68.1 cm (SD=2.21). CCLmin measurements from other nesting beaches are

Honduras 58.5-75cm, Guyana 68.1cm, Surinam 63-75cm, Colombia 52-75cm, Mozambique 65.4cm, Sri Lanka 68-79cm (Márquez 1990).

For the Leatherback which is said to be the fastest growing sea turtle, CCLmin was 154.3 (SD=5.50) and CCWmax was 110.0 cm (SD=5.14). Mean CCLmin Measurement from other nesting beaches are Trinidad 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 (Márquez, 1990). According to Márquez (1990), this species is not only the largest living sea turtle, but also one of the largest including extant reptiles. The largest Leatherback ever documented was a male of CCLmin= 256.5 cm and body weight of 916 kg, found dead on Harlech Beach in Gwyned (Wales) in September 1988.

Most of the sea turtles encountered were found nesting between 9:30 and 12:30 GMT. A few nested after mid-night. There appeared to be no correlation between nesting activity and lunar pattern and needs further investigation. This not withstanding, it was initially observed that the turtles nested when the moon was down. Later on, turtles were seen nesting during full moon nights. The Leatherback turtles seemed to nest mostly during half moon nights and when the moon was down. None of the turtles encountered had already been tagged. One might suggest that turtles nesting within the intensive study area belong to a distinct population members of which have not been tagged anywhere.

The numerous problems facing the coastal zone of Ghana include erosion and pollution. Some parts of the intensive study area face severe erosion. The main causes of erosion in Ghana as outlined by Armah and Amlalo (1998) include sand and pebble winning, hydrographic conditions such as reinforcement of onshore waves due to wave refraction from adjacent headlands. Erosion at some portions of New Ningo (Plate 12) and Old Ningo is so severe that if care is not taken most of the beach sand will be lost in the near future. This will eliminate sea turtle nesting as has been seen in the Mediterranean where large amounts of sand was removed from beaches for concrete production and other construction activities (Lutcavage *et al.*, 1997). At zone F, people continue to win sand even though it is prohibited (Plate 13). Others transport their bags of cement to the beach where they make blocks, before transporting them to their building sites or for sale. This has exacerbated the problem of erosion at Old Ningo. Tougher punishment should be meted against these culprits.

Pollutants such as garbage, is a problem around Prampram beach. The serious aspect of this is the high percentage of plastic products washed ashore amongst the debris (Plate14). The non-degradable nature of plastic makes it last longer on the beaches. Plastics are known to be the most common type of debris that sea turtles ingest. This has a serious effect on their digestive system and could eventually lead to their death (Plotkin and Amos, 1990)

During the 1999/2000 nesting season, a few sea turtles were found dead on the nesting beaches. Six Leatherbacks were found at zone F (Old Ningo). One Leatherback and two Olive ridley turtles were also found dead at Ada. The artisanal fishermen at both Old Ningo and Ada blamed offshore fishing trawlers for the death of these animals. A critical examination of one of the dead leatherbacks revealed that

Plate 12 Effect of sea erosion at zone E (New Ningo)

Plate 13 Sand winning activity at zone F (Old Ningo)

Plate 14 Debris washed ashore at Prampram beach

Plate 15 Recreational activity at the Prampram beach

the skull was crushed with an object. It was learnt that, some artisanal fishermen also kill turtles by hitting them with the wooden oars to prevent them from getting into their fishing nets. Incidental captures by shrimpers have accounted for more sea turtle deaths than all other sources of human activities combined (National Research Council, 1990). In Ghana, incidental captures of sea turtles in shrimp trawls have been reported by Nunoo and Evans (1997). Capture of sea turtles by shrimpers in Ghana must be evaluated as well as the subsequent introduction of the use of Turtle Exclusive Devices (TEDs). This will go a long way to protect sea turtles and also reduce the by-catch problems that are associated with the shrimping operations.

Sea turtles have very high ecotourism potential if carefully developed. As tourism is currently one of the most important foreign exchange earner for Ghana, this potential could be explored. In Tortuguero, (Costa Rica) park guards protect sea turtle nesting beaches, and 'turtle walk' trips are organized for tourists each night. This attracts lots of international tourists during the sea turtle nesting season. Apart from providing jobs for tour guides it also generates lots of income for local hotel and restaurant operators as well as souvenir shop owners. In an interview with some of the tour guides during the 1999 Green turtle nesting season, it was found that they make as much as two thousand dollars (US $2000.00) per month if the season is really good. The local community also generates income from the sale of permits for each tourist wishing to go on the turtle walk. The permits are purchased by the tour guides for the tourists. Proceeds from the sale of the permits are used for the community's developmental projects. This example can be emulated to provide alternate source of employment for some of our young fisher folks as fish landings continue to decline and the high cost of fuel makes most artisanal fishing operations less lucrative.

CONCLUSIONS

It may be concluded that only three sea turtle species nest on the shores of Ghana even if we have more than three in our coastal waters. The Olive ridley turtle continue to be the main nester on our beaches. The Leatherback turtle nesting population is likely to be higher than previously thought. The sea turtle nesting season in Ghana occurs between August and early April. Hatching success among the three nesting species are high. The emergence period for Olive ridley, Green turtle and Leatherback turtles are not quite different from that obtained from some other nesting beaches around the world. Some clutches laid on beaches between Prampram and Old Ningo are preyed upon by dogs whilst others suffer from tidal inundation. Threat to sea turtle eggs by dogs in the intensive study area is very pronounced, in that total destruction of nests during each nesting season could be as high as 40%. The protection of sea turtles in this area should be of major concern to wildlife managers.

Beaches along PrincessTown to Busua, Senya Bereku to Accra, Prampram to Ada, and Anloga to Denu provide good nesting grounds for sea turtles in Ghana. Interview with some of fishermen along the coast of Ghana showed that most of them were not aware that it was illegal to kill sea turtles. Only a few fishermen, 15.2% (total of 97) of them said they were aware it was illegal to kill sea turtles or collect their eggs. As much as 59.9% of the total interviewees have tasted and continue to eat turtle meat. Beach sand with median grain size between 0.2-0.4 mm (medium to coarse sand) and sorting coefficient between 0.4-0.7 (well-sorted to moderately well sorted) are those preferred by nesting sea turtles in Ghana. Nesting beaches at the intensive study area are under serious threat by sea erosion as a result of both natural and human activities.

RECOMMENDATIONS

It is clear that Ghana has a significant sea turtle population that needs to be managed as an endangered resource. The priority now is to acquire adequate knowledge base through research, and develop an integrated management approach. It is therefore recommended that:

- Long term research on nesting sea turtles along the coast of Ghana should be initiated, a minimum of 5 years. This should include tagging studies to quantify population size by rookery and population genetic studies in order to identify breeding units (stocks).
- Feeding area should be defined for each breeding unit.
- Public awareness on the need to protect sea turtles should be intensified. Community participation in the conservation process must be extended to other potential nesting beaches.
- Policies, plans and relevant legislation guiding coastal development should be formulated. This will protect turtle nesting beaches by keeping buildings far enough behind the beaches as has been done in the sultanate of Oman where the setback is 300 meters for areas adjacent sea turtle nesting beaches. Also control of lighting and protection of indigenous vegetation such as coconut trees would function as an effective screen for lights. This will go a long way to secure nesting beaches as urban centres keep spreading along the coast of Ghana. However, such policies require consultations among all stakeholders: government, private sectors and the local communities.
- Environmental issues, including the marine environment and sea turtles should be included in the school curriculum of the senior secondary schools.

- Programmes aimed at preventing the destruction of sea turtle eggs by dogs within the intensive study area should be initiated.

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