PILOT SEA TURTLE MONITORING AT IMS-METU BEACH, ERDEMLI, TURKEY (NORTH-EASTERN MEDITERRANEAN) USING NOVEL TRACKING SYSTEMS

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ABSTRACT

PILOT SEA TURTLE MONITORING STUDY AT IMS-METU BEACH, ERDEMLI, TURKEY (NORTH-EASTERN MEDITERRANEAN) BY USING NOVEL TRACKING SYSTEMS

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Nest counting is considered one of the most reliable techniques used for assessing sea turtle populations. There is a standardized sea turtle monitoring technique for Turkey published by the Ministries of the Environment, Forestry and Urbanization and Forestry and Water Affairs. Besides providing data on numbers of adult females and changes in sea turtle population sizes, this technique also provides additional information such as number of eggs per nest, number of hatchlings taking into account underlying relationships of environmental variables and ecological parameters with the nesting ecology of sea turtles. To understand the population trends monitoring studies must continue to be conducted. The reliability of overnight patrol surveys in nest counting technique which should be carried out by large numbers of qualified researchers to obtain accurate nesting data could be challenged due to long and demanding working hours requiring very dedicated researchers, and the simultaneous observation of a large patrol area. Another difficulty encountered in this technique is the formal protocol need to be adapted according to the characteristics of each field, facilities of the project and budget. To overcome these difficulties, the present study details a trial of a new monitoring system for two species of sea turtles (*Caretta caretta, Chelonia mydas*). This system adopts the aid of technology through the use of automated infrared cameras and laser barriers during the 2013 nesting season at the METU-IMS Beach in Erdemli, Mersin, Turkey. Although the natural state of the beach at METU-IMS is well preserved, there is no official protection status with respect to the conservation of sea turtles in this area. One of the main aims of this research study is the introduction of the METU-IMS. Beach as a formally recognized sea turtle nesting site. Another major aim of this study was the trial and evaluation of new monitoring methodology in order to save time and human effort compared to the current standard monitoring systems. It is intended to establish a monitoring procedure which can be applied easily and consistently in the following seasons and which complies with official standards. To test the accuracy and efficiency of this automatized monitoring system, standard monitoring daily patrols were conducted to gather data to be compared with results of the new system using infrared (IR) motion sensitive cameras and laser beam systems. The latter detected 85.71% of nesting female emergence with 14.71% false alarms. Both systems share the common aims of locating the turtles in order to record and count all adult females arriving on the beach, classify them according to track morphology, locate nests and investigate clutch success. With the use of both systems we were able to collect intensive data on the following; nesting activities of adult females, spatial and temporal distributions of the nesting attempts and nests, nesting success, nest density, incubation duration, clutch size, hatching success and important nest parameters affecting embryonic development like depth, diameter, humidity and temperature over the duration of the 2013 nesting season. In order to achieve the overall objectives, inter-related sub-objectives were addressed namely: identifying the potential of IMS-METU beach as a sea turtle nesting site and understanding the relations of environmental variables and ecological parameters with the nesting ecology of sea turtles on IMS-METU Beach. To identify correlation of environmental parameters with nesting and hatching success, the beach was characterized due to profiles of sand composition, size, sort and vegetation. Stranding data were collected and genetic studies were conducted. In addition to monitoring studies, informative activities were held intensely. The results enabled us to understand the conditions for a successful incubation period and the importance of

minimizing the anthropological threats. Continued research at METU-IMS beach may provide essential insights into the effects of climate change and coastal development on sea turtle ecology and conservation, provided that the terms of commitment towards long term studies and acquiring protection status for the breeding site are met. In conclusion, IR camera- laser barrier coupled system is found to be a promising tool for sea turtle nest monitoring substituting labor-intensive surveys. This system could be upgraded by image processing technologies via the visual fingerprinting and monitoring.
Keywords: Infrared camera, laser barrier, *Caretta caretta, Chelonia mydas*, Mersin, METU-IMS, image processing.

ÖZ

PİLOT DENİZ KAPLUMBAĞALARI İZLEME TAKİP SİSTEMLERİNİN ODTÜ-DBE KUMSALI'NDA, ERDEMLİ, TÜRKİYE (KUZEY-DOĞU AKDENİZ) UYGULANMASI

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Yuva sayma, deniz kaplumbağası popülasyonlarının değerlendirilmesi için kullanılan en yaygın tekniklerden biri olarak kabul edilir. Türkiye'de yapılan izleme çalışmaları için standart prosedür Çevre ve Şehircilik Bakanlığı ve Orman ve Su İşleri Bakanlığı ortak katkıları ile belirlenmiştir. Yuvalayan ergin dişi kaplumbağa sayıları ve popülasyon içindeki değişimi belirlemesinin yanı sıra, bu teknik, aynı zamanda yuva başına yumurta sayısı, yavru sayısı, yavru başarı oranı gibi pek çok veri ile çevresel ve ekolojik parametrelerin yuvalama ve yavru başarısına etkisinin anlaşılmasına destek olur. Popülasyon trendinin belirlenebilmesi için uzun zamanlı sürerli veri toplanması gerekmektedir. Belirlenmiş prosedür çok sayıda kalifiye araştırmacının gece devriye yöntemi çalışmalarını gerektirmekle beraber; uzun bekleme süreleri, nitelikli araştırmacı için harcanması gereken zaman ve bütün bölgenin eşzamanlı gözlem zorluğu gerekçeleri ile eleştirilebilir. Bir diğer nokta ise; her yuvalama kumsalının ekolojik ve fiziksel şartlarına, proje kaynaklarına ve bütçeye göre ortak protokolün uyarlanmasının gerekliliğidir. Bu tezde, Mersin, Türkiye'de bulunan ODTÜ -DBE Sahili 2013 yuvalama sezonunda yuvalayan iki tür deniz kaplumbağaları (*Caretta caretta, Chelonia mydas*) izleme çalışmalarının teknolojinin katkısıyla otomatize kızılötesi kameralar ve lazer bariyerler kullanılarak geliştirilen yeni bir izleme yöntemi uygulanmıştır. Hızlı şehirleşme ve yanlış

yapılaşma tehditleri altındaki sahil şeridinde doğal özelliklerini koruyabilen nadir bölgelerden biri olmasına rağmen ODTÜ-DBE kumsalının deniz kaplumbağaları açısından herhangi bir resmi statüsü bulunmamaktadır. Tezdeki ilk hedef, bölgeye resmi bir koruma statüsü kazandırabilmektir. Böle önemini vurgulamak için veri toplanması esnasında deniz kaplumbağalarını asgari insan etkisine maruz bırakmak, zaman ve iş gücü kazancı sağlayabilecek, sürerliliği kolayca sağlanabilecek ve belirlenmiş resmi standart prosedürün tüm gerekliliklerini karşılayabilecek bir metot uygulaması tezin takip eden ikinci ana amacıdır. Bu amaçlar çerçevesinde yeni uygulamanın doğruluğunu ve etkinliğini karşılaştırmalı test edebilmek için, standart günlük devriye izleme çalışması da eş zamanlı uygulanmıştır. Güvenlik sistemleri düşünülerek uyarlanmış lazer bariyer sistemi yüzde 85.71 anaç çıkışını alarmla bildirmiş fakat alarmların yüzde 14.71 i çalışma konusu dışındki aktivitelerden meydana gelmiştir. Her iki yöntemde de yuvalayan dişilerin sahilde veri toplanması için coğrafi konumunun belirlenmesi belirlen, izleri okuyarak veri toplanması, yuva yerinin belirlenmesi ve yavru başarısının takibi aynı tekniklerle belirlenmiştir. Her iki yöntemi kullanarak, genişletilmiş amaçlarla bu tez kapsamında 2013 yılı üreme sezonu için; ergin yuvalayan dişi kaplumbağa sayısı, başarılı- başarısız yuvalama aktivitesi, yuvaların mekânsal ve zamansal dağılımı verileri toplanmıştır. Bunlara ek olarak; yuvalama başarı oranı, morfolojik ölçü, yuva yoğunluğu, kuluçka süresi, yumurta sayısı, yavru başarı oranı ve embriyonik gelişimi etkileyen yuva derinlik, çap, nem, sıcaklık verileri de kayıt altına alınmıştır. Çevresel parametrelerin yuvalama ve yavru başarı oranları ile ilişkilerini izlemek amacı ile eğim, profil, kum kompozisyonu, tanecik düzeni ve şekli, bitkisel örtü belirlenerek sahil karakterizasyon çalışmaları yapılmıştır. Sahile vuran ölü- yaralı kaplumbağa verileri toplanarak, genetik çalışmalar da yapılmıştır. Etkin sonuç elde edebilmek için bilgilendirme faaliyetlerine de yoğunluk verilmiştir. Sonuçlar, başarılı kuluçka dönemini etkileyen faktörlerin ve antropolojik tehditleri minimize etmenin öneminin anlaşılması sağlamıştır. ODTÜ-DBE Sahili'nde sürekliliği sağlanacak izleme çalışmaları iklim değişimi ve yuvalama alanlarının tahribatının deniz kaplumbağaları üreme ekolojisi üzerindeki etkilerinin ve koruma yöntemlerinin belirlenmesine katkıda bulunacaktır. Otomatize kızılötesi kamera ve lazer bariyer izleme yöntemi güvenilir hassas veri toplanması ve işgücünün azaltılarak araştırmacıya zaman tasarrufu sağlanması konularında umut verici sonuçlar vermiştir. Yöntem görüntü işleme teknolojisi ile görsel veri üzerinden birey tanımlanması çalışmaları ile güncellenerek standart bir teknik olarak önerilme konusunda gelecek vaat etmektedir.

Anahtar Kelimeler: Kızıl-ötesi kamera, lazer bariyer, *Cartta caretta*, *Chelonia mydas*, Mersin, ODTÜ - DBE, görüntü işleme

To my family...

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Abbreviations	**Description**
CCL	Curved Carapace Length
CCW	Curved Carapace Width
CITES	The Convention on International Trade in Endangered Species of Wild Fauna and Flora
IUCN	International Union for Conservation of Nature and Natural Resources
MTSG	Marine Turtle Specialist Gpoup
SCL	Straight Carapace Length
SCW	Straight Carapace Width
SWOT	The State of the World's Sea Turtles
TSD	Temperature- dependent sex determination

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CHAPTER 1

INTRODUCTION

1.1 The Sea Turtle

In this chapter, background information on the fossil records of sea turtles and about currently existing species based mainly on the taxonomic approach is given. The general biology of sea turtles section is divided into subtopics including; evolutionary adaptations and anatomy, their ecological role, distribution and habitat, life cycle, natal homing of females, and developmental stages covering reproductive behavior. To emphasize the importance of and need for sustainable management and conservation plans, the molecular approach for unit assessment is also included. Unit assessment conducted with the aid of genetics is valuable for assessment of population trend dynamics. The literature survey on sea turtle monitoring studies has been narrowed down spatially beginning from the Mediterranean to also cover Turkey but more specifically is concentrated on Mersin Bay. This information is provided to draw attention to the importance of the selection of appropriate monitoring methods for sea turtle protection. The correct monitoring method will give accurate and reliable data which in turn will strengthen the source of action plans. Finally, the threats will be covered that totally influence demographic features of sea turtles are addressed. At the end of this chapter, the basic needs for risk assessment are covered to bring the management and conservation issues to the fore.

1.1.1 Background Information

The similarity between terrapins and tortoises provide the clues about their being closely related fuelling the idea that todays terrestrial tortoises had an aquatic parent. While the earliest fossil terrapins come from the Oligocene period around 30 million years old, the first fossils of shelled reptiles, that is the first marine turtles, to return to the water come from the Upper Jurassic being around 150 million years old. Sea turtles therefore have an ancient history. Fossil records of ancestors of modern sea turtles date as far back as 110 million years [1] [2]. The earliest fossil form of the modern sea turtle was identified as *Santanachelys gaffneyi* found in Eastern Brazil sediments belonging to the Early Cretaceous period [1]. Sea turtles were represented by more than a hundred species divided into 50 genus belonging to four families (Cheloniidae, Dermochelyidae, Toxochelyidae and Protostegidae) at the end of the Cretaceous period. Among them only two families (Cheloniidae and Dermochelyidae) could survive to the present day as diverse marine radiations of crytodiran turtles [3].

Regnum: Animalia
Phylum: Chordata
Classis: Reptilia
Subclassis: Anapsid
Ordo: Tesdudinata
Subordo: Cryptodira
Familia: Cheloniidae

Currently, seven species are clearly recognized. The Chelonioidea superfamily
İs represented by these recent families; The Cheloniidae family included the Green turtle (*Chelonia mydas*), Loggerhead (*Caretta caretta*), Flatback (*Natator depressus*), Hawksbill (*Eretmochelys imbricate*), Olive Ridley (*Lepidochelys olivacea*), and Kemp's Ridley (*Lepidochelys kempi*), while the monotypic Dermochelyidae family comprises the Leatherback (*Dermochelys coriacea*). There is debate among scientists on the eight species known as "black" turtles of the Pacific coasts of the western hemisphere, generally referred to as *Chelonia agassizi* or sub-species *Chelonia mydas agassizii*. Molecular studies support the theory that these Pacific turtles are a multipigmented subpopulation of Pacific lineage [4] [5] [6].

1.1.2 Sea Turtle Biology

This chapter is organised under the following headings: Evolutionary adaptations and anatomy, ecological role, distribution and habitat, life cycle, natal homing and developmental stages covering reproductive and nesting behavior of sea turtles. It also covers unit assessment through genetic studies, a literature survey on sea turtle monitoring studies and the threats they face.

1.1.2.1 Evolutionary Adaptations and Anatomy of Sea Turtles

Terrapins and turtles are representatives of life forms which begin their existence on land and return to the water. Swimming and the density of the sea water itself help sea turtles to reduce some of the problems that having a heavy cumbersome shell brings to their land-living tortoise counterparts since weight is much less of a handicap with the help of buoyancy. Parasites which adhere to their shell can be cleaned more easily in the marine environment, with the volunteer cleaning services provided mainly by fishes. However, their dependency on land to lay their eggs is the major disadvantage to their way of life. The morphology of sea turtles has derived in order to adapt to life as sea creatures. As a monophyletic group of the suborder Cryptodira, the existing poikilothermic sea turtles share common characteristics such as closure of their jaws by contracting muscles over the cartilage on the otic chamber The life evolving from water the mechanisms run adaptations to survive. [7], a retracted head in a vertical plane assuming an S-shape between the shoulder girdles [8]. Further examples of adaptation to life in sea water show that their lighter carapaces reduce the extent of the internal bony shield so that the ribs project beyond its margin on both sides. The nearly complete skull roofing confers protection to the head compensating for the reduced head retraction ability of the living sea turtles. Other adaptations summarized in [9] [10] are the presence of hypertrophied paddle-shaped forelimbs (flippers) and streamlined shells characterized by a reduced amount of bone to improve hydrodynamic efficiency. Movement is aided by thrust on anterodorsal and posteroventral movements produced by flippers; and reduced drag due to the fusiform body shape and minimal head and limb pockets. Well-developed pectoral muscles attached to the enlarged shoulder girdle with elongate coracoid are useful for swimming [11]. Tear glands are modified to remove extra salts from body fluid to balance osmotic pressure. The physical forms of animals provide the clues on their behaviour, ecology and physiology. Anatomy supplies the raw data for evolutionary, taxonomic and population studies and the external anatomy namely the head, body and snout (prefrontal) scales, the shell scutes, the limbs and body form is a useful tool widely used for species identification [10]. Other clues generally used for identifying the species are color and jaw forms [12] [13]. With ageing, the color of the plastron turns to cream. While Green turtle hatchlings seen in Figure 1.1-1a are black in the dorsal position and white in the ventral position, the colouring of Loggerhead hatchlings seen in Figure 1.1-1b could range dorsally from dark gray to brown and ventrally (the plastron) from pale to dark brown.

(a) *Chelonia mydas* hatchling

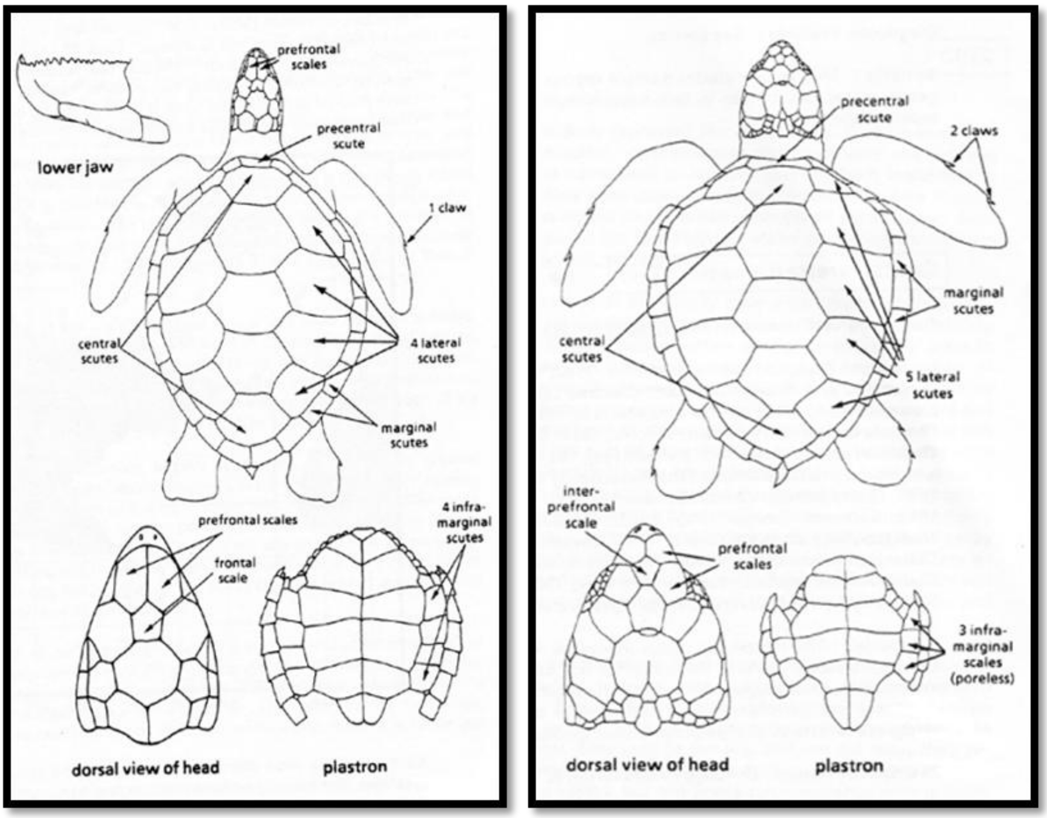
(b) *Caretta caretta* hatchling

(c) *Chelonia mydas* adult

(d) *Caretta caretta* adult

Figure 1.1-1 Pictures of *Caretta caretta* and *Chlonia mydas* turtles during hatching and egg laying taken by the author of this study

With growth the carapace of the Green turtles shown in Figure 1.1-1c becomes gray-green to mottled shades of brown and black; the carapace of the juvenile and adult Loggerheads shown in Figure 1.1-1d varies from browns to green [14] [15] [16]. The keratinous upper and lower jaws, named as rhampotheci, differ with diet [17] [18]. In contrast to *Caretta caretta*, the mainly herbivorous *Chelonia mydas*, the lower jaw rhamphotheca has small cusps and edges and is surrounded by spike-like serrations or denticles [16]. The omnivorous *Caretta caretta* feeds upon heavily armored prey [19], and has robustly constructed rhamphotheci with a crushing layer and cutting surface along the posterior margin [10]. The upper jaw is pointed. Scutes, thickened parts of epidermis covering the skin and head are the most commonly used tools for identification due to their easy recognition. The number of and positioning of the scutes are species-specific. The terminology of scutes is as follows: the carapacial (upper shell) scutes along the midline are labelled as vertebral (central), running in a lateral position to these are the costal (lateral) scutes and those located most anteriorly along the midline are the nuchal scutes. Inframarginals are found along the point of connection between the carapacial and plastral scutes, which are intergular, gular, humeral, pectoral, abdominal, femoral and anal from an anterior to posterior direction [15] [14] [16]. The green turtle can be identified easily by four pairs of costal scutes with the nuchal scutes touching the vertebral scutes. They have four pairs of inframarginal scutes. Their head is small relative to the body and their beak is rounded. In contrast, Loggerhead turtle have five pairs of costal scutes touching both the first lateral and first vertebral scutes. They have three pairs of poreless inframarginal scutes. As can be understood from its name, the head size of Loggerheads is relatively large in comparison to body size. Green turtles have one pair of pre-frontal scutes with Loggerhead turtles having two or more pairs pairs [14]. A final distinctive difference between these two species is the crawling tracks left on the sand. Loggerheads make irregular marks by alternating movement of their front flippers, while Green turtles produce symmetrical marks through simultaneous movement of the front flippers as well as leaving a center drag mark from the tail. In contrast to Loggerheads, Green turtles leave much deeper and larger body pits with multiple pits in a single crawl [20]. Figure 1.1-2 compares both species.



a) Scutes of *Chelonia mydas* b) Scutes of *Caretta caretta*

Figure 1.1-2 Comparison of *Caretta caretta* and *Chelonia mydas* [20]

The juveniles approaching adulthood and the adult sea turtles have dimorphic tails which is extend beyond the border of the carapace with a closer cloacal opening to the plastron for males [16]. Chelonian skulls include a secondary palate composed of bones forming an inner braincase containing the brain, and outer bones which house the sensory organs and supply attachment points for the jaw, neck and throat muscles [21]. The complete forms of the skull, form and pattern of the bones on the mouth and details of palate vary in different species [15]. Having a rounded skull, a short snout and shallow notches. Green turtles differ from Loggerheads which have a larger skull and wider snout tapering to the orbits. In comparison to Green turtles with a palate that have a pair of ridges parallel to the the jaw, Loggerheads with longer palates lack alveolar ridges [10]. The parts of the brain change with ontogeny in size. The brain is larger in hatchlings and juveniles than in sub adults and adults proportionately [16]. Similar with the other turtles oceanic turtles have eight cervical vertebrae, beginning with atlas, articulating with the skull and culminating with attachment to the carapace. The sliding joints allow limited dorsa ventral bending opposing little twisting of the neck. The intramembranous bone joints, vertebrae and ribs produce the bones of the carapace, while the epiplastron, hyoplastron, hypoplastron, and xiphiplastron and the entoplastron constitute the bones of the plastron [10]. The major head muscles are responsible for opening and closing of the jaw, while the appendicular muscles functioning in adduction, retraction, rotation, and flexion of the flippers. Pursuing this further, the dorsal pectoral muscles function in the abduction, extension, and protraction of the flippers [16]. Respiratory muscles mainly coordinate the changes in body volume during ventilation [10]. With respect to the senses of sea turtles; morphological, electrophysiological and behavioral studies help to understand the structure, function and mechanisms. Beginning with vision; the return by both hatchlings and adult females to the sea underlines their ability to use visual cues limited to diffuse images, levels of brightness and contrast [22]. This emphasizes the necessity for control of anthropogenic light sources reaching nesting areas. As a result of morphological studies it is understood that visual photoreceptors are responsible for both visual acuity and color perception [23] [24]. Marine turtles are sensitive to the colors with wavelengths in the spectrum between 450-620 nm [25] [26] [27] and have visual acuity [28] [29] further consolidated by the behavioral studies. On the topic of hearing, and the lack of an external ear, it is thought that based on aquatic niche selection with each ontogenetic stage parallel to the changes in the sensory environment, adaptations have evolved [30]. The facial tissue continues with the tympanum [31]. As a unique characteristic of sea turtles, the stapes and oval window jointing saccular wall via fibrous strands relaying vibrational energy of the stapes to the sacule [32]. In the same way, cochlea releases fluid pressure [33]. To summarize, sea turtles are insensitive to the high frequencies while they are thought to respond to a range of lower frequencies [33] [32]. Concerning the olfactory sense it has been claimed that they are unable to detect chemicals underwater anatomically [34] [35] [36]. Contrary to anatomical findings, behavioral studies indicate that water is moved by throat-pumping over the nostrils for olfaction [37] [38]. The chemical imprinting hypothesis also supports the proposal that chemical cues enable identification of the natal beach by nesting females [39].

1.1.2.2 Ecological Role of Sea Turtles

Defining the ecological roles of sea turtles have been improved by interaction with programs including archaeo-historical data, traditional environmental knowledge, and marine ecosystem models with basic model constructed at the individual, population and ecosystem scales with detailed information for each scale commonly using energy and nutrients to build interactions within each level. At the individual level, digestive processing and individual productivity could be determined, followed by the needs of the population level as population growth parameters, and finally ecosystem level covering all interspecific interactions increases the complexity of the model [40]. Before constructing models and their resolution quality, firstly how this system works in nature must be understood. Sea turtles have important roles in marine ecosystems with their prey- predator status in the food web providing a healthier environment, and transportation of nutrients within the marine and terrestrial environment [41]. In the first place, prey- predator interactions, varying through ontogeny have behavioral and ecological importance on population dynamics, and life histories. This can be seen by the feeding behavior of Green turtles, being the only species primarily herbivorous, [42] which function as both grazing and browsing herbivores creating a healthier environment [43], and also showing omnivorous characteristics [44] [45] [46] [47] [48]. Continuous cropping of the same sea grass plot removes blades allowing them to float [49] [50] rather than accumulating on the bottom thus preventing: a decrease in nitrogen supply to the sea grass roots, overgrowth of the sea grass leading to obstruction of currents, seabed shading and decomposition. Grazing also promotes the growth of other plants benefitting animals within this environment and influencing the densities and food web dynamics [51]. Loggerhead turtles in neritic habitats forage mainly on benthic prey which helps sediment mixing [52] [53]. This feeding on hard-shelled prey plays a role in reducing the prey shells into smaller discarded particles increasing the disintegration rate and nutrient cycling. Enhancing the sediment not only affects the compaction, aeration and nutrient distribution but also diversity of species and dynamics of the benthic ecosystem. Furthermore prey-predator interactions are beneficial to understand the mechanism of sea turtle habitat shifts with their different life stages [54]. Both Loggerheads and Green turtles feed on jellyfish. The addition of the Leatherbacks to this group makes them top predators of the jellyfish that prey on fish eggs and larvae. From another perspective, sea turtles are also prey for different animals during their changing life stages. Most vulnerable to predation as eggs, hatchlings and juveniles, they supply food for many terrestrial animals like; ants, crabs, rats, raccoons, foxes, feral cats, dogs, crows, mongooses and vultures benefiting from a nutrient-rich source of food. Emerged hatchlings provide another feeding opportunity for natural predators including also seabirds. Hatchling in water face continued predation from seabirds, and fishes. Once turtles have grown to full size, the risks of predation are greatly reduced since they have very few natural predators other than killer whales and sharks. One reason for ontogenic shifts in habitat use could be the avoidance of juveniles small in size from predators in neritic habitats till reaching a certain body size [55]. Humans also play an important role which affects turtle survival both through intentional hunting and by-catch similar to the predation risk [56] [57]. So, awareness of the human predation factor is important to fully understand the anthropogenic disturbance of turtles alongside nesting habitat destruction, marine pollution and light and noise pollution [58]. Secondly, their impact on nutrient cycling from water to land by maintaining a healthy environment for other marine life thereby influences balancing the food web [59]. Not only are they themselves feeding areas maintaining habitats for epibionts like barnacles, algae and other organisms, they also provide food sources for shrimp and fish, some of whom establish cleaning stations providing a service to the sea turtle by reducing drag and cleaning the head and skin. Furthermore, nutrient transportation on land occurs with nesting attempts of females and developmental stage of eggs influencing process behind formation of the beaches and sand dunes. As a dynamic geological location, beaches are formed by eroded continental material washed to the oceans by streams and rivers. After being suspended in the water column, this material is transported along the coast by littoral drift [60]. The wave action gradually returns the sand and sediments back to the beach with varying seasonal intensity resulting in the re-creation of a sandy beach known as a platform. While these seasonal patterns produce a wider shape with a flatter slope to the beach in summer than the winter profile, the shape of platform is also affected by other parameters like grain size composition, beach slope and sediment type [60]. Sea turtle eggs and nutrients carried by nesting females from the foraging areas have direct and indirect effects on vegetation, sand dunes and stability of sandy shorelines as shown in Figure 1.1-3 [61].

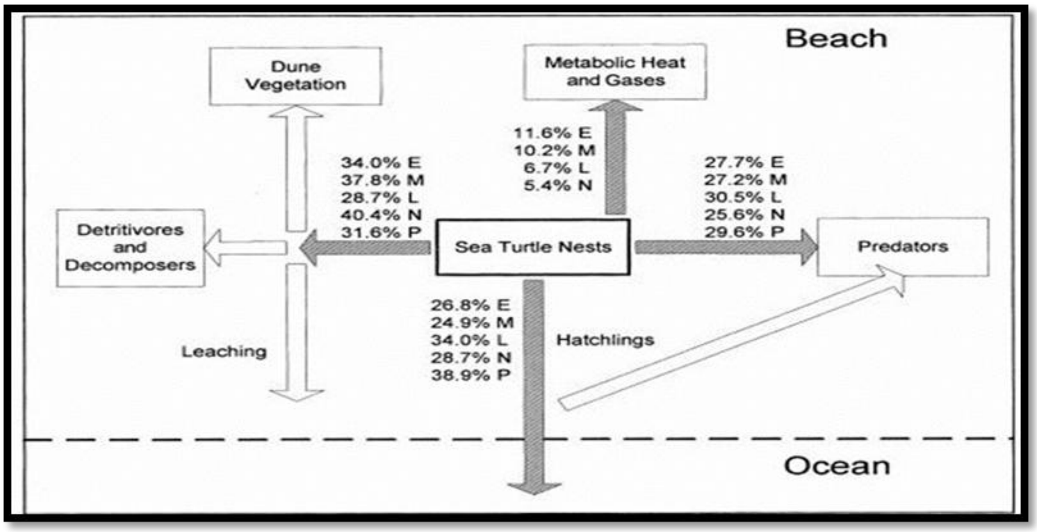


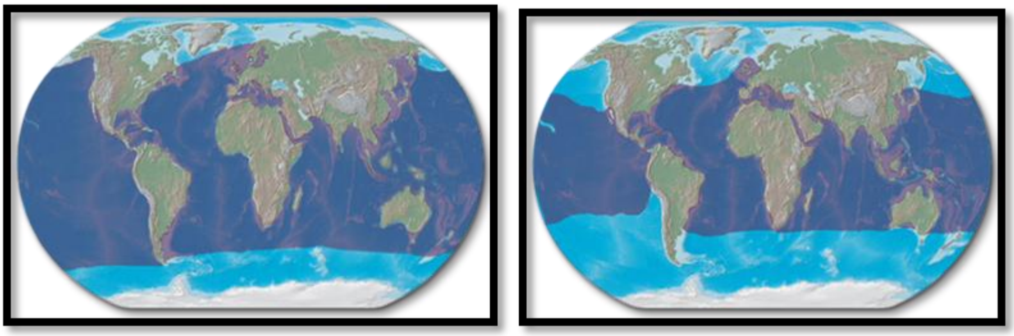
Figure 1.1-3 Movement of nutrients and energy introduced into nests [61]

*Melbourne Beach, Florida, by Loggerhead sea turtles, values of percentages are represented as E for energy, and for each nutrient M for organic matter, L for lipids, N for nitrogen, and P for phosphorus. Shaded arrows indicate pathways, while open arrows indicate quantities

Sand dunes are critically endangered ecosystems which provide socio-economic benefits and coastal protection and support a wide variety of highly endemic flora and fauna. Sand dunes important to succession supply perfect substrate for plants to set root. Pioneer plants stabilizing sand dunes are often grasses that have special adaptations like tolerance of high salt, waxy and rolled leaves to avoid water loss and exposure to evaporation. The main mechanisms for providing stabilization are roots binding the sand, decreasing wind speed and reducing erosion with the leaves. Pioneer plants are followed by other plants with a progression of vegetation changing the characteristics and structure of substrate. Step by step the dune becomes more suitable for the next vegetation type. With time, the dunes move inland accumulating more and more sand. Eventually more vegetation grows on those dunes. Thereby, the types and density of vegetation indicates the age, length and stability of dunes. Although establishment of grasses could occur within a season, shrubs need 10 to 20 years to become established. With the passing of decades or even centuries a maritime forest could be established. In the case of removal of the forest or any steps of succession for development, the vegetative balance is disrupted. To sum up, sea turtles help to stabilize dunes by supplying nutrients to beach ecosystems, through their own nesting habitat. The introduction of nutrients and energy while females lay their eggs differ with the fates of sea turtle eggs. When sea turtles hatch, nutrients are returned back to the sea in the form of hatchlings, whilst some remain in the nest namely embryonic fluid and eggshells; whereas unhatched eggs enter the detrital food chain. Moreover, eggs which are preyed by root systems support nutrient and energy supplies for predators and plants [62] [63]. These processes help to supply and distribute nutrients driving nesting beach dynamics. As can be seen in Figure 1.1-3 taken from a study for Loggerhead turtles nesting on Atlantic beaches of Florida* large quantities of marine-derived nutrients and energy moved into the beach with an estimated 25% of organic matter, 27% of energy, 34% of lipids, 29% of nitrogen, and 39% of phosphorus from-nests entered marine habitats as hatchlings. 29-40% of all nutrients remained in the beach available for detritivores, decomposers, and plants whereas 26-31% of nutrients were utilized by nest consumers [61].

1.1.2.3 Habitat and Distribution

Marine turtles are totally adapted for life in the aquatic environment, dependent on the land only for egg laying (nesting females) and reaching the sea (hatchlings) [64].



a b

Figure 1.1-4 Distribution of Loggerhead and Green turtles around the world

a) Distribution of Loggerhead turtles shown - shaded areas [66]
b) Distribution of Green turtles shown - shaded areas [66]

They are distributed circumglobally throughout temperate and tropical regions including the open ocean, continental shelves, bays, lagoons and estuaries with different ecological niches being inhabited by different species [65]. The Loggerhead turtle is distributed in subtropical and temperate waters across continental shelves and estuarine areas in the Atlantic, Pacific, and Indian Oceans as shown in Figure 1.1-4a (shaded areas) [66] [62]. The herbivorous Green turtle is distributed circumglobally in tropical and subtropical oceanic waters of the Atlantic, Pacific, and Indian Oceans seen in Figure 1.1-4b (shaded areas) [66]. A habitat model of sea turtles could be generalized for the different life stages as; early juvenile nursery habitat- later juvenile developmental habitat- adult foraging habitat and adult inter-nesting or breeding habitat. It is seen that turtles share similar habitat utilization and migrations with larger fishes and cetaceans as shown in
Figure 1.1-5 [54].

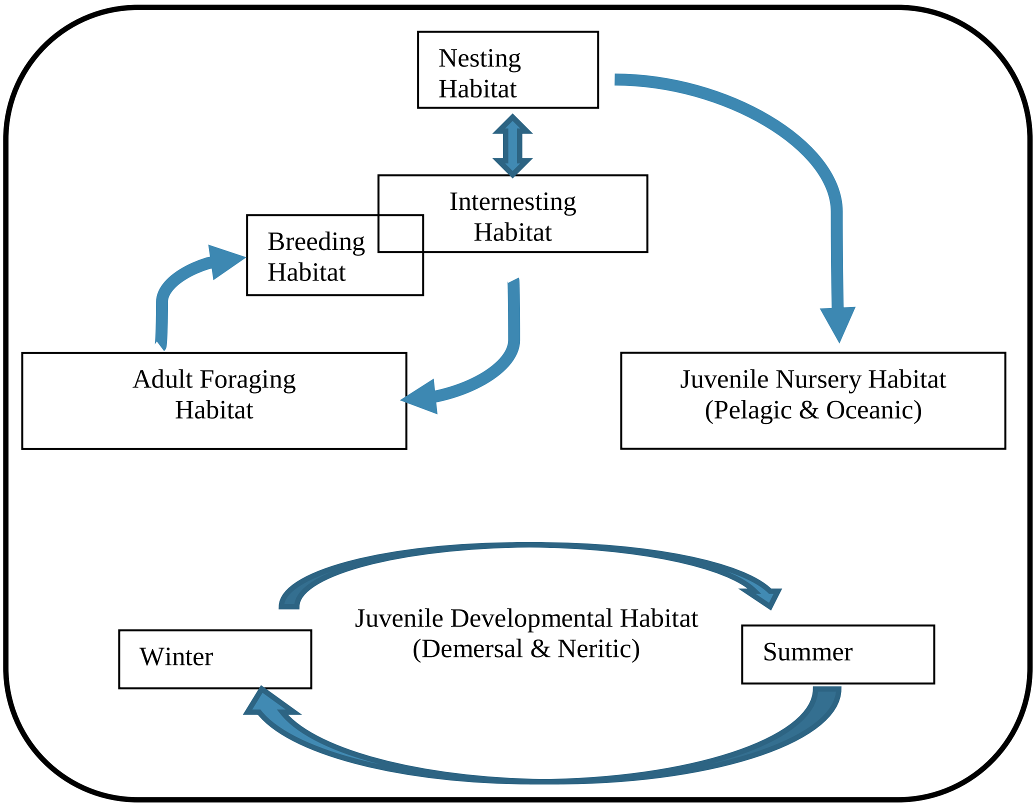


Figure 1.1-5 Conceptual model of ontogenetic habitat stages in sea turtles [54]

Data accumulated by mark-recapture and telemetry studies demonstrate that resource driven migrations occur between feeding and breeding areas with changing intervals [67]. Highly migratory Loggerheads are capable of traveling long distances [9].

Female Loggerheads migrate towards natal beaches about every 3 years to lay an average of four clutches approximately every 2 weeks [62]. For female Green turtles, migration occurs [9] every 2–4 years with a high degree of fidelity laying an average of three clutches at 10- to17-day intervals [64].

1.1.2.4 Life Cycle

Being long-lived, slow growing reptiles, sea turtles have complex life history patterns. To fully distinguish best management actions, the intricacies of the sea turtle's life history must be understood [55]. A generalized life history model based on observations of Green turtles [68] was developed first and further elaborated upon by many authors for all sea turtles [69]. Three basic ecosystems in which sea turtles are found are described as the; Oceanic zone, Neritic zone and Terrestrial zone. The Oceanic zone covers the open ocean environment exceeding two hundred meters depth to the bottom, replaced by the Neritic zone where depth is less than two hundred meters including the continental shelf. The Terrestrial zone is where the egg laying, embryonic development and hatching occurs [70]. Studies show that adult sea turtle migrations between breeding and feeding areas are resource driven. Characteristics have evolved to manage environmental variability and unpredictability such as variations in resources both spatially and temporally resulting with ephemeral breeding habitats [67]. It is proposed that, three types of life history patterns for different species of sea turtles as follows:

Type 1: The Neritic Developmental Pattern refers to complete development in the neritic zone.

Type 2: The Oceanic -Neritic Developmental Pattern refers to early juvenile development in the oceanic zone and later juvenile development in the neritic zone.

Type 3: The Oceanic Developmental Pattern refers to complete development in the oceanic zone.

From an evolutionary perspective, it is highly probable that ancestors were resident in the coastal salt marshes, estuaries, and tidal creeks thereby showing characteristics of the Type1 life history pattern. A change to the Type 2 pattern may have resulted from selective pressures to exploit new food resources with fewer competitors in the oceanic zone or to avoid the higher predation risks in the neritic zone. Although Loggerheads and Green turtles exhibit seasonal and ontogenetic shifts in habitat occupation, both species belong to the Type 2 life history pattern as summarized in Figure 1.1-6 [71]. In this study the Type 2 pattern is detailed represented by boxes referring to life stages and the corresponding ecosystems, solid lines refer to movements between life stages and ecosystems; dotted lines are speculative in Figure 1.1-7 [71].

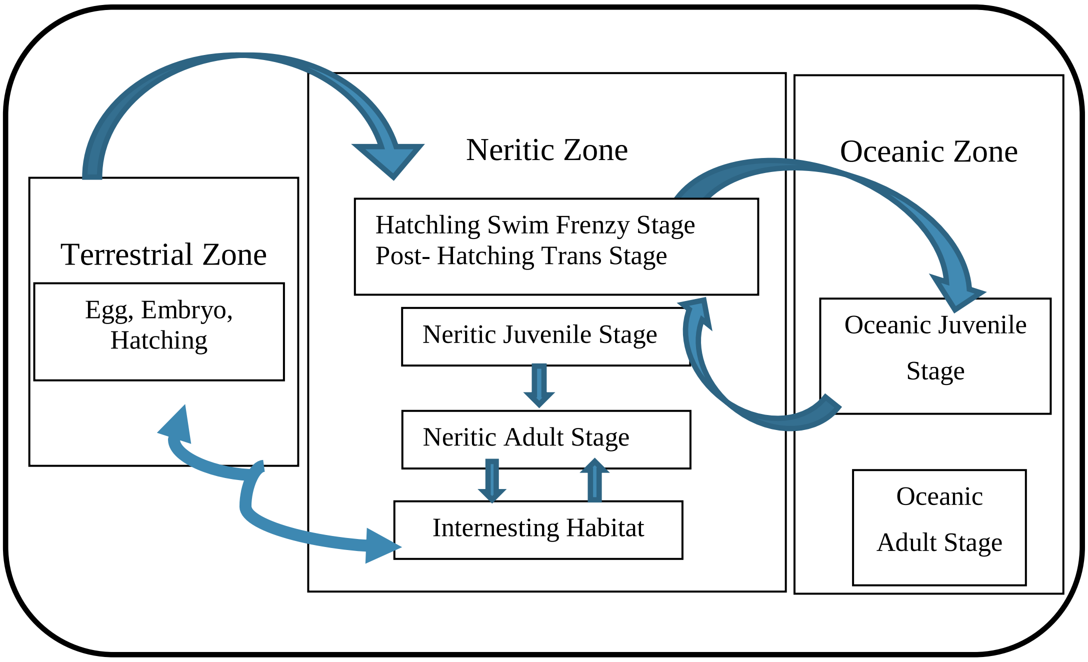


Figure 1.1-6 Type 2 life history pattern (From [71])

Commences with the emergence of hatchlings that orient towards the sea using visual cues and the low elevation of light horizons. Apon entrance to the water, they swim without pausing for 24-48 hours known as the swim frenzy stage [72], during which many are predated while the survivors use the energy from the remaining yolk. On completion of this stage they pass through the first transition period. The post hatchling begins to feed and moves from the neritic zone into the oceanic zone by swimming in a perpendicular direction to the wave fronts [55]. The oceanographic and meteorological clues like currents and winds help to direct the post-hatchlings to actively position themselves by using magnetic cues [73]. After a developmental period in the oceanic zone lasting from 7 to 11.5 years, termed the lost years, they leave the oceanic zone and complete their development in the neritic zone [54] [74]. The second transition period is the recruitment of epipelagic turtles from the oceanic habitats to the neritic habitat where they are benthic [75] [76] [77]. Adults may leave neritic habitats during their reproductive migrations between the adult foraging areas in the neritic zone and internesting habitat. While maturing over the course of several decades, they face many threats resulting in low survival to adulthood. Being such excellent navigators, they are able to migrate hundreds or even thousands of kilometers between foraging and nesting grounds.

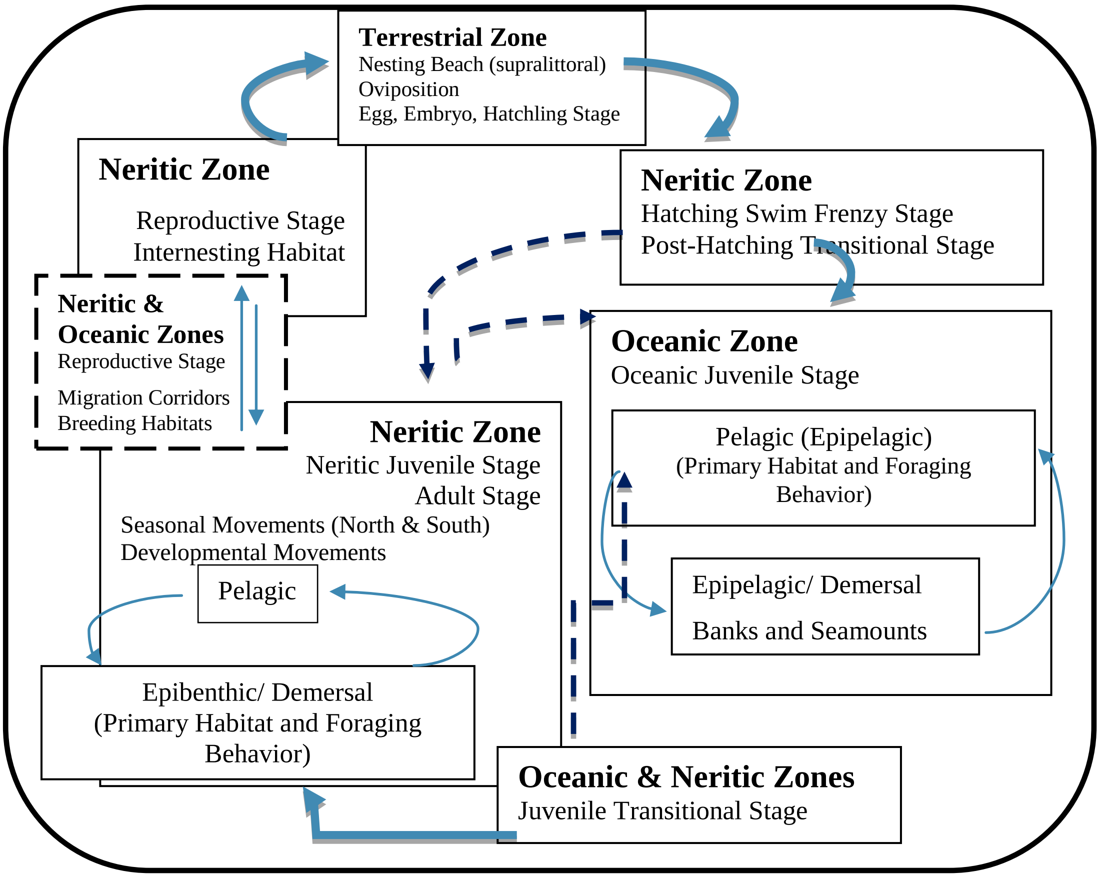


Figure 1.1-7 Detailed life history diagram sea turtle [71]

1.1.2.5 Natal Homing

The act of long distance reproductive migrations of mature females returning from feeding grounds back to the same beaches on which they hatched many years earlier is known as natal site philopatry or natal homing. Although - such migration incurs huge costs in terms of energy, some of the main motivation factors are integrated with; external-internal factors, ability of motion, navigational skills, distant food sources, avoidance of bad seasonal conditions and escape from predation. Tracking studies in the form of mark-recapture developed into satellite tracking need a long-term data supply in order to provide the knowledge to test this hypothesis. Thanks to modern day genetics procedures, the rate of attaining this knowledge continues to expand. One hypothesis predicts that each nesting colony should involve an isolated maternal lineages group [78]. This hypothesis could be tested by whether the nesting populations are isolated via female transmitted traits like mitochondrial DNA resulted from females returning to their natal beaches. On the other hand, there is an alternative Social Facilitation hypothesis proposed by Hendrickson [79] claiming experienced breeders are followed by inexperienced nesting females from the feeding areas to a specific nesting place and continue to use this site for all follow up nesting attempts. The Social Facilitation hypothesis is expected to result in high rates of female mediated gene flow between beaches of common feeding grounds which could be tested by male-mediated gene flow at nuclear loci resulting with complex population structuring. Mixed-stock analyses show that multiple nesting colonies could create feeding aggregates reducing breeding populations across the region. Moreover, the mtDNA studies offer multiple paternity occurring in the range of 0 - 100%, and 9–100% within species. Although the mechanism behind natal homing cannot be explained clearly, it is thought that they use mainly chemoreception [80] or magnetic elements as light inclination angle and intensity [81] as a cue.

1.1.2.6 Developmental Stages, Reproductive and Nesting Behavior

Land dependence is purely for egg laying for Loggerheads and Green turtles as for most of the other species. Females nest every 2.5 to 3 years (range 1 to 9 years) [62]; laying on average 112.4 eggs per clutch (range 23 to 198) [82]; on sandy oceanic beaches. This multiyear cycle nesting strategy, depending on oceanic conditions influences survival and growth. The frequency of nesting could mask population declines caused by anthropogenic factors [83]. An individual female may mate with several males; as many as three different fathers may fertilize the eggs of a single clutch demonstrated by the help of genetic studies [64] resulting in the finding of the sperm storage capacity of females for up to several months between remigration intervals. After fertilization; the follicle develops into the yolk coated with albumen. Formation of the inner shell is followed by the coating of aragonite crystals to form the outer shell membrane. Following these developmental stages and the finding of a proper nesting place the eggs are oviposited along with a liquid. Due to the lack of parental care, delaying reproduction in order to lay larger clutches with a larger egg size are strategies to benefit and increase the survival chance of the hatchlings [69]. The nesting activity on the beach can be divided into seven steps as follows: beaching, bed making (digging the body pit), nest digging, egg laying, covering up, camouflaging and returning to the sea. Within the incubation period, if the air temperatures are unseasonally cool, the incubation period may extend. Conversely if the air temperatures are unseasonally hot it may shorten but this is also affected by other parameters such as humidity, oxygen penetration, color and particle size of sand grains, physical structure of the beach, local climate and metabolic heat. Internal development of the egg does not proceed beyond middle gastrulation lasting four to eight hours after oviposition [64] following the attachment of the embryo to the upper-most point of the eggshell understood from a white spot. Next the size increases resulting with covering of the entire outer shell membrane and development of multiple membranes, including the vitelline, amnion, allantois, and chorion membranes [64]. The embryo is positioned adjacent to the yolk sac to receive energy and chemical needs from the food that the adult female had foraged prior to laying the eggs [64]. The temperature during the second third of incubation is critical due to temperature-dependent sex determination (TSD) in sea turtles, also reported for the Loggerhead [84], and Green turtle [85].

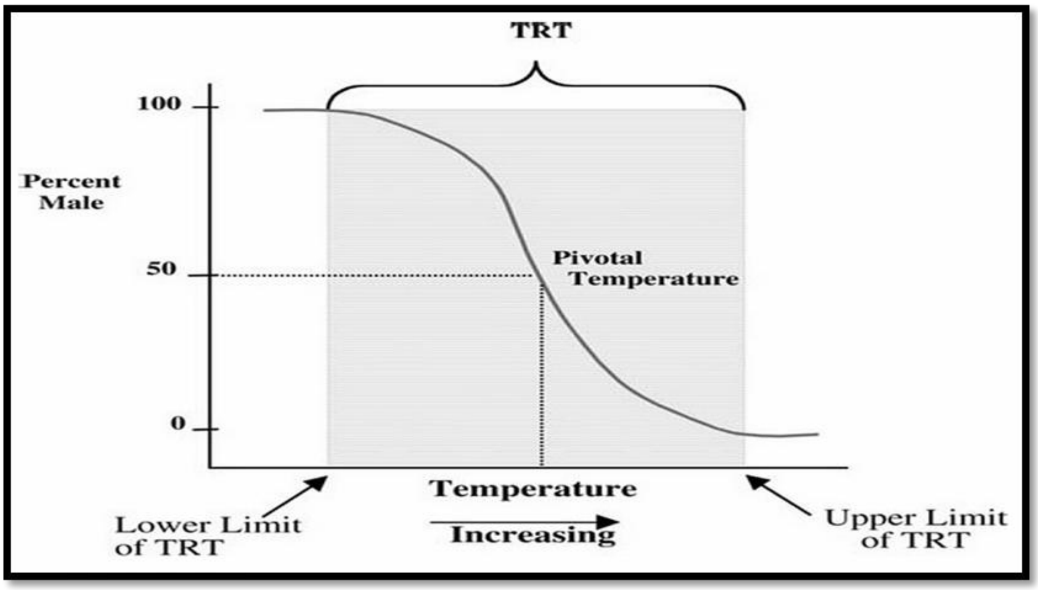


Figure 1.1-8 Pattern of temperature-dependent sex determination in sea turtles. [84]

The general pattern of TSD is shown in Figure 1.1-8. From the graph, the transitional range of temperatures (TRT) shows the range of temperatures determining the ratio of sex shift from 100% male to 100% female. Another important term known as the pivotal temperature is the point that will produce an equal sex ratio and varies both interspecies and intraspecies. The biochemical mechanism determining sexual differentiation via temperature is the regulation of aromatase, an enzyme which plays a role in the conversionto testosterone or estrogen. During the female differentiation process, the cortical epithelial tissue thickens and medullary cords degenerate, the reverse process occurs in the male differentiation process whereby the cortex does not proliferate, and the medullary cords do not regress creating the seminiferous tubules [86] [87]. The incubation period ends with the hatchling slitting the eggshell with a temporary egg tooth called a caruncle on their beak. At the time of hatching, hatchlings are still encased within an external egg sac. In the following few days the hatchlings absorb the yolk sac into the body cavity via a hole in the plastron named as an umbilical hole. In addition post-hatching flattening of the carapace enables the hatchlings to begin to move upward towards the surface of the nest by helping each other in periodic outbursts [64]. The impulse for this negative geo-taxis powered by the residual yolk is social facilitation. When the hatchlings do reach the surface, the high daytime temperatures render them inactive until cooler temperatures allowing their emergence(usually corresponding to late nightfall/post midnight) are reached. Daytime emergences may result as exceptions e.g.cloudy rainy days. The main advantages of nighttime emergences are protection from high temperatures which could be lethal and avoidance from diurnal predators like birds.

1.1.2.7 Genetic Studies for Unit Assessment and Barcoding

Clarifying nesting populations is important to understand the units of assessment. With the affinity for specific nesting sites by forming subpopulations vulnerable to extinction, males provide gene flow by breeding with females that have various nesting-site affinities. This occurs over a potentially larger geographic scale and defines the geographic upper limits of the nesting populations [88] [89] [90]. Sharing key demographic features like fecundity, sex ratio, survivorship, and recruitment, a population, as an interbreeding group has a degree of reproductive isolation and demographic cohesiveness. In the conservational approach these are often termed management units. Isolation between the populations could be spatial, temporal or behavioral and in some cases a group of interconnected populations that have some genetic exchange form a metapopulation [91], having the importance as potential reservoirs of genetic diversity that retain local or regional adaptation [92]. This metapopulation could determine an evolutionary significant unit in conservation; a distinct population segment; and a regional management unit fitting the natural history of sea turtles [90]. Some of the major obstacles of observing sea turtles directly are; the prolonged generation time and oceanic habitat of juveniles making the use of genetics to identify populations more beneficial than alternatives like tagging. As one of the earliest genetics techniques protein electrophoresis demonstrated low genetic variability in Green turtles and Loggerheads relative to the other vertebrates [93]. With the enhancement of genetic understanding and tools, techniques such as Restriction Fragment Length Polymorphisms [94], Anonymous Single-Copy Nuclear DNA [95], Minisatellites [96], Random Amplification of Polymorphic DNA [97] were used to create infrastructure for mitochondrial DNA control region sequences with the aim of testing ages and isolation of Green turtle nesting populations, and providing genetic evidence in supporting the natal homing hypothesis. In addition, hypervariable microsatellite techniques [65] are used to demonstrate multiple paternity together with promising technique such as single-nucleotide polymorphisms [98] and mitogenomics. All these studies have resulted in significant contributions to the knowledge about natal philopatry and multiple paternity. Also, mixing stock analyses have been used to solve processes behind the turtles at mixed foraging areas showing that the complexity of sea turtle migratory patterns could differ both interspecies and intraspecies. The increase of studied microsatellite loci is not only used as a genetic tag but also helps to understand mating strategies. Management Units have been defined for Green turtles [99] [100] [101] and Loggerhead turtles in both the Atlantic and Mediterranean [102] [103] [104]. Following such progress, recently, barcoding studies have become one of the leading international programs to catalogue the biodiversity [105]. The barcoding of threatened species provides an identification system besides allowing rapid classification systems for the illegal hunting of species and enhances taxonomic understanding being helpful in developing appropriate conservation strategies [105].

1.1.2.8 Sea Turtles in Mediterranean

The Mediterranean Sea is connected to the Atlantic Ocean through the Gibraltar Strait and is bordered by 46,000 km of coastline, of which 2577 km belongs to Turkey. The beaches of Turkey cover 606 km of this coastline [106]. In the light of the knowledge and information obtained, the interest in Mediterranean Sea Turtles has been increasing especially over the last three decades [107]. Within 5 species of sea turtles (*Caretta caretta*, *Chelonia mydas*, *Eretmochelys imbricata*, *Lepidochelys kempii*, *and Dermochelys coriacea*) found in the Mediterranean only two; the Loggerhead turtle and the Green turtle, breed along the coasts of the Mediterranean. Although the Leatherback turtle has been recorded more widely, the two remaining species, the Hawksbill and the Kemps Ridley have only been sighted occasionally [108]. The nesting areas of *Caretta caretta* of higher density in the Mediterranean have been reported from Greece [109], Turkey [106], [110], [111], [112], [113], Libya [114] and Cyprus [115], [116]. On the other hand, Tunisia [117], [118], Syria [119], Israel [120], Egypt [121], Lebanon [121], and Italy [121] are Mediterranean countries with a lower Loggerhead turtle nest density. The Green turtle (*Chelonia mydas*) shows a nesting site preference for the eastern Mediterranean. Two of the most important nesting sites are found in Turkey [106], [112], [113], [122], [123], [124] and Cyprus [115]. There are no records for the central and western parts of the Mediterranean [125]. When the nest numbers are taken into consideration it is understood that, Turkey, as a nesting site, is the most important region for Green turtles [125] and the second most important region for Loggerhead turtles [121]. The results of genetic analyses show that there is partial isolation between the Mediterranean and Atlantic Loggerheads with low nucleotide divergences [102], [126] at least at the female level [127], [76] with sub-populations across the Mediterranean basin [97]. Greater spatial variation have increased gene flow among populations whereas less vagile species tend to have more structured populations [128], [129]. The only limited gene flow between Mediterranean and Atlantic Loggerhead populations and philopatry of the females have shown that, Atlantic loggerhead turtles as an origin of the Mediterranean populations [127] also enter the Mediterranean to share foraging habitats [107], [130]. Opposing an inverse relationship between nesting population size and mtDNA diversity [131], [132];

some small populations with very low diversity have also been observed. By the help of these results; it could be confirmed that the Mediterranean populations of Green turtles and Loggerhead turtles were established by the small number of females from the Atlantic migrators which may have occurred after the last glacial period [133]. In contrary, the evidence also supports the possibility that the diversity of Mediterranean Loggerhead populations resulted from the short postglacial history [97]. Although with the recent knowledge suggesting a population substructure with reduced gene flow among the groups of rookeries like Greece, Cyprus, Turkey and Israel [134], it is expected that other genetically differentiated units will be recognized by larger sampling and more specific genetic markers [107]. In spite of the fact that the mechanism of female natal homing could not be understood completely yet, some studies have been focusing on the sea surface currents and water masses to explain the structuring of the feeding areas of the western Mediterranean. Loggerhead colonies of Turkey are important management units diverging significantly in mtDNA haplotype frequencies [76], [134], [80]. It is also shown that Turkey has the highest diversity amongst other Mediterranean countries [135]. The population of Green turtles nesting only on the beaches of Cyprus and southeastern beaches of Turkey [136] originated from the Atlantic supported by analyses of both mtDNA and nuclear DNA. These studies offer impact of founder effect followed by genetic drift resulted with a low mtDNA and relatively higher microsatellite DNA variation in the region resulting in a unique genetic structure that could be considered as a management unit. Extinction here would virtually reflect the Green turtle population from an entire sea basin, emphasizing the need of very high conservation priority.

1.1.2.9 Sea Turtle Studies in Turkey

The The first approved scientific representation of sea turtle studies in Turkey was made by Hathaway in 1972 mentioning the high probability of *Caretta caretta* and *Chelonia mydas* nesting on the beaches of Turkey [124]. Following and supporting the first study; two Loggerhead turtle carapaces in the Izmir region and another Loggerhead turtle carapace in Koycegiz was reported [137]. After this report, a *Caretta caretta* specimen was donated to the Ege University Museum collection [138]. These evidences of the existence of sea turtles along the Turkish coastlines helped to gather interest and provide momentum for increasing studies. The first detailed studies along Turkey's beaches were conducted by Geldiay and his team in 1982 focusing generally on Dalyan, Kumluca, Belek, Side and Alanya beaches leading to the identification of sea turtle nesting grounds in 1989 [139], [140], [141], [142]. With the increasing efforts in other areas covering the whole Mediterranean coastline of Turkey, scientists identified 17 important nesting grounds listed from west to east as follows; Ekincik, Dalyan, Dalaman, Fethiye, Patara, Kumluca, Kale, Tekirova, Belek, Kızılot, Demirtas, Gazipasa, Anamur, Goksu Delta, Kazanli, Akyatan and Samandag [106] as seen in Figure 1.1-9. Within this categorization thirteen of the beaches are accepted as high density with the nests being continuously studied [113], [122], [123] and the remaining four beaches as with a lower density of nests. In 2003 Loggerhead turtle nesting was reviewed and the official number of nesting sites increased to 20 [143]. The compatable nature of the Turkish Mediterranean for sea turtle nesting provides the opportunity to identify new nesting sites with increasingly more studies being conducted in places which had not been studied previously. This has resulted in the addition of new nesting sites to the list namely Alata [144], Davultepe [145], Tuzlu, Karatas, Agyatan, Yelkoma and Yumurtalik based on the studies of Canbolat [146]. Besides population dynamics, the other related topics such as ecology, embryology, reproductive ecology, fisheries bycatch and genetics have been studied in Turkey and Cyprus.

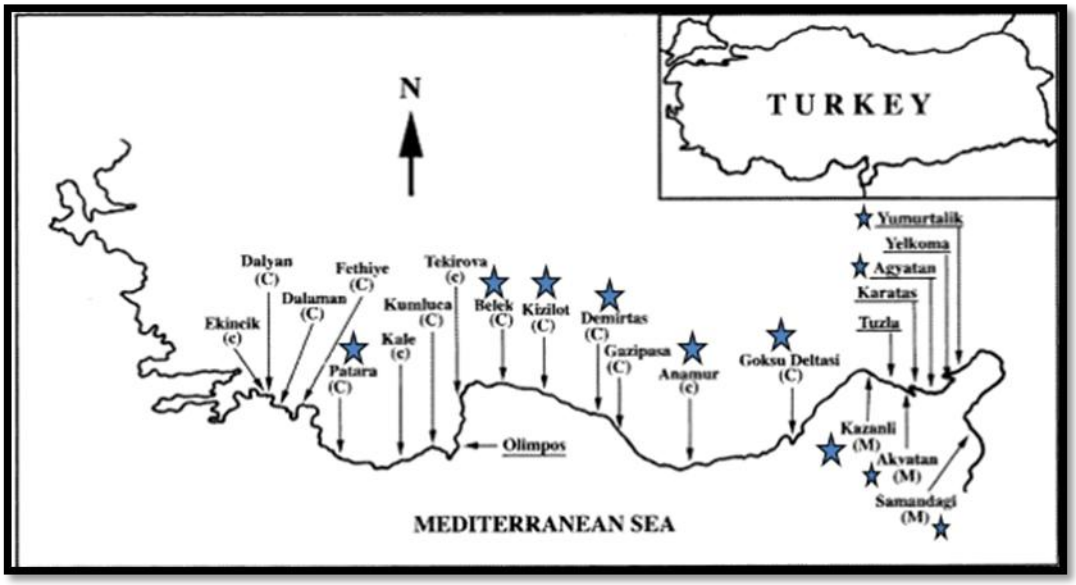


Figure 1.1-9 Important sea turtle nesting sites in Turkey [106]

C: High density for C. caretta, c: Low density for C. caretta, M: High density for C. mydas; High and low density beaches are given according to [106]. The six underlined sites are added by [147]. Star signed locations represent the regions in where both species are nesting modified from the data taken from [107].

Ecology covers a wide range of topics like impacts of invertebrates [148], [149], [150] and mammals [151], [152] on hatchlings and eggs, insect infestation [153], [154], morphology [155], [156], carapacial scute variations [157], [158], relocation of the nests [159], [160], heavy metal accumulation on tissues [161], physiological parameters of blood [162] and foraging areas [163].

Ecological studies can also be linked by other topics like the relationship between hatching success and ecological-physical parameters of the environment [143], destructive impact of erosion on nesting sites [164], impact of fisheries on sea turtles [165], [166], prawn trawls excluding sea turtles [167]. Embryology includes studies on developmental stages [168], [169], [170], embryonic mortality [171], reproductive ecology and success [172], albino [173], [174] abnormalities [174], late [175] embryos and hatchlings temperature dependent sex determination [176], [177], [178], [179], natural temperature regimes [180] and effects of predation [181] on sex determination. With the growing interest, studies on the genetics of sea turtles also increase daily [130], [134], [182], [183]. Although nesting sites have been monitored, important marine areas for sea turtles are less closely studied. In contrast to the wide range of literature information on the nesting ecology of sea turtles in Turkey, studies on the feeding and wintering areas of sea turtles and existence of juveniles have a recent history with increasing focus only recently. The small amount of knowledge obtained from limited studies demonstrates that Kadirga Cape, Karagelme Bay and Samucak Cape are used as mating regions, while the surroundings of Kas- Kova Island, Suluada and Tekirova are reported as feeding regions for Loggerhead turtles [184]. Extended studies show that the region between Mersin and İskenderun is used for breeding, feeding and overwintering supported by a report showing 78.3% of turtles caught by trawl boats during winter as a sign of existence of non-migrant marine turtles in the area [165]. Stranded turtles along the Turkish coasts have indicated that residing Green turtles were found in shallow waters adjacent to nesting beaches along the Çukurova region coast [106]. These findings were also supported by clarification of juvenile presence in the Çukurova region [165]. From the data obtained from juvenile strandings at Samandağ, it is further demonstrated that this region could be used by Green turtles for foraging activities presenting the probability of its being a Green turtle juvenile developmental area [185]. Moreover, Fethiye Bay could be one of the feeding grounds for Green turtles [163]. Initial results provided by satellite tracking studies consolidate that both Loggerhead and Green turtles travel along the coasts of Turkey, Cyprus, Syria, Libya, Egypt and Tunisia. Tracking research conducted around Akyatan beach on two Green turtles showed that the first turtle initially followed a path from Akyatan to Cyprus and continued through Egypt to eventually reach Libya's Gulf of Sidra. The results from the second turtle showed the path taken was between Alanya and Manavgat. The number of turtles fitted with transmitting devices from the Sea Turtle Rehabilitation Center in İztuzu- Dalyan has reached sixteen continuosly providing valuable information. Other reports showed that one of the six turtles released from Northern Cyprus migrated to Turkey using the path between Antalya and Kızılot as foraging and wintering grounds [186].

1.1.2.10 Previous Studies in Mersin Bay

Five of the nesting beaches of Turkey; from west to east, Anamur, Goksu Delta, Kazanli, Alata, Davultepe are located within Mersin city boundaries; among which short or long term sea turtle population studies have been conducted [136], [166], [144].

While Anamur and Goksu are located on the western side of the METU-IMS, the others; Kazanli, Alata, and Davultepe are situated on its eastern side.

Anamur Beach which covers an Archeological SIT Area and consists of Anamorium and Mahmure Castle, is facing threats mainly due to sand extraction and pollution. It was demonstrated that Anamur beach supports 8.8% of the total Loggerhead turtle nesting potential in Turkey [146] [166].

Goksu Delta Beach, consisting of a network of channels which has special status as a Ramsar and 1st degree Natural Site, lies mainly in the Goksu Delta SPA (Special Environmental Protection Area) and is among the most important of nesting grounds for C. caretta, It is officially listed as an important 'Reproduction and Conservation Zone for Water Birds' as well as Wildlife Conservation Site. The major problems for this area are considered to be the high tide line and high predation rate of the Golden Jackal to both hatchlings and adult females. Also the trace impacts of the former Paper factory and sumer houses increasing in number were reported [107]. Several research groups have studied this delta [113], [122], [187], [188], [189], [190], [191], [192], [193], [194].

METU-IMS Beach, was characterized and monitored for the first time in this study. Characterization of the basic ecological features of the beach at METU-IMS in terms of suitability for sea turtles nesting here was the main motive for this study with the aim of ascertaining a new nesting area formally. The METU-IMS campus has 1000 meters of sandy beach used by *Caretta caretta* (Linnaeus, 1758) and *Chelonia mydas* (Linnaeus, 1758) as a nesting area, and a harbour inhabited by the soft shelled Nile turtle, *Trionyx triunguis* (Forskal, 1775) as a part of their living area (sunbath & food).

Alata Beach is the nearest official nesting area to METU-IMS. As for METU-IMS, Alata beach is used by both species as a nesting beach [146] and was declared a 1st degree natural site in 2000. The beach is well protected since it is located next to the Alata Horticultural Research Institute owned by the Ministry of Agriculture. Monitoring studies at Alata began in 2002 [195]. It was recognised as an important nesting site in 2005 [196] and monitoring activities have been continuing since then [197]. In 2008, a study on the relationship between variation in numbers and mortality rates showed that there was no relation [198]. In 2011 microsatellite locus analysis of Green turtles conducted with samples collected in the 2006 nesting season showed there were high differences in GT repeat numbers between alleles [199]

Kazanli Beach monitoring studies have been continuously carried out with the aim of clarifying the main factors affecting the breeding success and how agricultural, industrial and city originated pollution affect it [200].

Davultepe 100. Yil facilities; public beach and picnic area run by Mersin Environmental Protection Foundation (MEÇEV). Special protection measures were proposed for this beach [145].

Also there is a Ph.D. Thesis entitled “Population Genetic Structure of the Green Turtle (*Chelonia mydas*) in the Northeastern Mediterranean” which includes samples from Alata, Goksu and Kazanli suggesting the uniqueness of Mediterranean Green turtles be considered as a management unit [201]. Following this, another Ph. D. thesis named “Population Genetic Structure of the Loggerhead (*Caretta Caretta*) in Turkey” also includes samples from Anamur, Goksu, Kazanli and Alata and states there is no genetic structuring among nesting beaches in terms of DNA based on the mtDNA results of five described management units in Turkey [202].

1.1.2.11 Threats

It has been estimated by the WWF [203] that the Mediterranean Sea receives 10 billion tons of urban and industrial waste every year. It has been suggested that solid waste and wastewater exceed carrying capacity in the location where tourism is high creating a high seasonal demand and as a consequence pollution has a negative effect on the water quality located in beach areas and their drinking water supplies. Although tourism provides economic benefits to the country in the long term it has devastating implications on human health and the environment, plus most of the physical environmental profits are largely directed out of the country. There are increasing conflicts between the tourism sector and local inhabitants due to limited resources including water, food, sanitation, energy and land uses. Over the years, the Turkish Mediterranean coastline has been drastically modified for touristic purposes such as the mass construction of hotel complexes, holiday homes, shops and other buildings for recreational purposes. The process of urbanization also has enormous impacts on the coastline and can increase pollution, land degradation and loss of biodiversity found in these ecosystems [204]. Hall [205] stated that unplanned and poorly managed tourism development can have a huge impact on the natural ecosystem. It has been estimated that nearly 60 percent of the Turkish population live in coastal regions covering an area of over 8,000km^2 with one of the highest demands generated by touristic activities [206]. The consequences of urbanization are affecting sensitive ecosystems located around coastal areas [206]. In a study conducted by Sesli and Karsli [207] it is shown that together with the loss of artefacts of cultural and historical merit, the natural coastal beauty has been lost in many places due to the mass development of buildings and hotels in coastal areas where many environmental problems are occurring including pollution and coastal erosion. Natural coastal areas are a major target for property development, resulting in destruction of water sources, biodiversity loss and many other environmentally destructive endeavors. A number of studies suggest that the pressure in Turkish coastal regions is caused by input of organic material, chemical pollution and nutrients mainly derived from industry, intense urbanization (relocation of native people and tourism) and maritime and agricultural activities [206], [207], [208]. One of the four large Turkish coastal cities is Mersin which has a combined urban and rural population of 1,705,774 (2013) with an estimated increase in the population rate of 29% [208], [209]. A number of studies highlight that one of the pressures specific to the Mersin area has been important atmospheric inputs from the North Levantine [210], [211], [212]. WWF has warned that if the tourism continues increasing this will have a huge impact and cause "lots of damage to landscapes, causing soil erosion, put pressure on endangered species, further strain available water resources, increases waste and pollution discharges into the sea and lead to cultural disruption" [203]. One of the examples mentioned by the WWF is that most of the sand dunes on the Spanish Mediterranean coastline are now lost due to urbanization and tourism development. In Italy over 43% have been lost to urbanization mainly linked to urban development where there are very few stretches of 10 to 20 km coastlines found without construction. One of the worst possible types of damage to world heritage is the loss of species. It is estimated that over 500 plant species in the Mediterranean are threatened with extinction because of the continual pressure from increasing tourism demands for development [203]. One of the biggest impacts tourism has on the critically endangered Monk seals is that of habitat loss. They require sheltered caves and beaches to breed successfully and these continue to be exploited by the tourism industry at an alarming rate [213]. A recent review of sea turtles in the Mediterranean [146] proposed that as many as 150,000 turtles are estimated to be caught yearly as bycatch in the basin, probably leading to over 50,000 deaths. All sea turtle species are protected under the CITES Appendix 1 agreement, which means that trade in any sea turtle product is illegal, but fisheries by-catch, hunting , habitat destruction, and other environmental factors have severely reduced the marine turtle populations [214].

1.2 Major Objectives

Since 1975, the presence of the Institute of Marine Sciences campus has made it possible to protect the natural ecology of this region among the neigbouring beaches faced with corruption due to growing interest in tourism and increasing human population. Despite the well preserved status of IMS- METU beach, it as yet has no official sea turtle protection status put the region under the danger of wrong urbanization. In this thesis it is aimed at introducing IMS-METU Beach as a formal sea turtle nesting site. After drawing attention to the new nesting site at IMS, METU Beach, the second main aim of this study is a trial of the new monitoring methodology to save both time and human power for standard monitoring systems. There are interconnected sub-objectives to achieve these overall objectives as analyzing the nesting densities, nesting and hatching success of *Caretta caretta* and *Chelonia mydas* on IMS-METU Beach, understanding relations of environmental variables and ecological parameters with nesting ecology of sea turtles on IMS-METU Beach.

1.2.1 General Objectives

In this study the two main points which must be emphasized are; recognizing IMSMETU Beach as a formal sea turtle nesting site and developing easy applicable monitoring protocol for sustainable data collection for the foreseeable future.

1.2.1.1 Introducing IMS-METU Beach as Formal Sea Turtle Nesting Place

The Turkish Mediterranean coasts are of a suitable nature for sea turtle nesting which gives us the opportunity to realize and identify new nesting places with more studies conducted to those places which had been not studied before. This could result in the addition of new nesting places to the ones already recognized formally. With this motivation the researchers must make progress step by step. Firstly, usage of the beach by sea turtles must be shown by scientific data collected with protocols signed by ministries. Even though the scientists of the Institute of Marine Sciences were aware that there were nesting sea turtles on IMS-METU Beach, this is the first time scientific data has begun to be collected with this study funded by the BAP-07-01-2012-001

(Scientific Research Project) “Characterization of METU-IMS Coasts’ Ecological Features in terms of Sea Turtles”.

1.2.1.2 Developing A New Technology For Monitoring Nesting Sea Turtles

The literature search conducted to decide on the methodology of the study showed that in spite of some efforts to make nesting beach monitoring protocols compatible, global standardization has not been achieved as yet. It appears that methodologies differ mainly due to the specific aims of individual projects, characteristics of the study area, available manpower and financial support. With this aim, SWOT which is a growing partnership among the Oceanic Society and IUCN MTSG with the participation of local organizations, scientists and conservationists, introduced Minimum Data Standards (SWOT 2011 One of the most important benefits of using these standards while collecting data is contribution to the datasets for future analyses of turtle’s abundance and long term monitoring. In order to create a common language between all the sea turtle studies from around the world, there are some key points which must be routinely included. “The Action Plan for the Conservation of Mediterranean Marine Turtles Adopted within the Framework of the Mediterranean Action Plan” [215] was taken into consideration and followed in the field survey. Within the declarations and agreements under the responsibility of Turkey, the General Directorate of Nature Conservation and National Parks as a unit of the Ministry of Forestry and Water Affairs appointed the Sea Turtle Scientific Commission of Turkey. This commission defined an action plan and implemented standard data record sheets. Taking all these SWOT Data Standards, the IUCN Action Plan for the Conservation of Mediterranean Marine Turtles and plan of the Sea Turtle Scientific Commission of Turkey, both short and long term objectives were defined. After this, the study field was characterized. In addition to the theory, field survey experience was gained in Dalyan, Mugla thanks to Prof. Dr. Yakup Kaska and his entire team for their collaboration and contributions. As manager of The Sea Turtle Rescue Center (DEKAMER) which was established following the RAC/SPA (Regional Activity Center/Special Protected Areas) guidelines (RAC/SPA, 2004), Prof. Kaska and his team spend valuable effort to conserve turtles and nesting beaches, to rehabilitate and apply medical support to injured individuals and to create public awareness. Moreover, to increase human and financial resources a project was submitted to METU- BAP (Scientific Research Project). As a result a protocol was prepared and presented to the Ministry of Forestry and Water Management. In this study, this protocol was used as a field survey guide and project was supported by METU-BAP-07-01-2012-001.

One of the most standard techniques used for assessing sea turtle populations is considered universally as nest counts. Besides providing data on numbers of adult females and changes in the sea turtle population size, this technique supports also additional information like the number of eggs per nest and number of hatchlings. Due to inter annual variations in nesting behavior of sea turtles the number of nests vary from year to year. Females usually lay several clutches in a breeding season and undertake cyclical migrations from feeding grounds to nesting sites at variable intervals, most commonly 2-3 years [64]. For Mediterranean populations the clutch frequency is estimated as 2.9-3.1 per female for green turtles and as 1.8-2.2 per female for loggerhead turtles. The median interval between nesting seasons for green turtles is accepted as 3 years, and for loggerhead turtles as 2 years [216]. There are many different methods to monitor turtle populations. Sea Turtle nesting period studies require overnight patrol surveys which should be carried out by a large number of qualified researchers to obtain accurate nesting data. The main disadvantages of these studies are; long waiting times, lack of dedicated researchers, and simultaneous observation of the whole area. It has been proved that, usage of motion sensitive infrared cameras and laser barriers in the sea turtle surveys reduces the excessive amount of work and minimize the number of project researchers required, by the BAP07-01-2012-001 (Scientific Research Project) “Characterization of METU-IMS

Coasts’ Ecological Features in terms of Sea Turtles”. METU-IMS has 1000 meters of sandy beach that are used by *Caretta caretta* and *Chelonia mydas* as a nesting area, and a harbor used by the soft shelled Nile turtle *Trionyx triunguis* as a part of its living area (sunbathing & food). During the 2012 and 2013 summer periods (15 May-15 September) sea turtle nesting activities were observed by using an Automated Camera Laser Beam System, followed by further use in the 2014 nesting season (which is excluded from this thesis).

1.2.2 Sub-Objectives

The motivation of fulfilling the targeted general objectives linked to sub-objectives were established before developing the methodology of this study. To meet the sequential steps of declaring a new nesting site there are two linked sub-objectives namely, identifying the potential of METU-IMS Beach as nesting sites for *Caretta caretta* and *Chelonia mydas* and understanding the relationships between the environmental variables and ecological parameters with the nesting ecology of sea turtles on IMS-METU Beach.

1.2.2.1 Identifying the potential of METU-IMS Beach, Erdemli, Mersin, Turkey as nesting sites for *Caretta caretta* and *Chelonia mydas*

The existence of nesting sea turtles on IMS-METU beach must be supported by scientific data in order to proclaim a new nesting place. Monitoring throughout the entire nesting season will be examined. There is a standardized sea turtle monitoring technique stipulated for Turkey and released by the Ministry of Environment, Forestry and Urbanization and the Ministry of Forestry and Water Affairs. Besides providing data on the numbers of adult females and changes in the sea turtle population size, this technique also supports additional information such as the number of eggs per nest and number of hatchlings supported by understanding of the underlying relations of environmental variables and ecological parameters with nesting ecology of sea turtles linking these two sub-objectives. To understand the population trends, monitoring studies must continue to be conducted.

1.2.2.2 Understanding Relations of Environmental Variables and Ecological Parameters with Nesting Ecology of Sea Turtles on IMS-METU Beach

With this study it is aimed to characterize METU-IMS beach used by nesting loggerhead and green turtle females to shape monitoring activities for high success rate and to decrease the impact of human disturbance on neighbouring nesting sites comparable with no human disturbance on METU-IMS Beach could be seen from Figure 1.2-1. It could be clearly observed that Kocahasanli situated on the easternward border of METU-IMS is threatened by huge buildings located close to the sea as shown in Figure 1.2.1a. On the western side, Limonlu is mainly affected by usage of the sandy area as a camping site as shown in Figure 1.2.1b.

Comparatively, there is no human pressure on METU-IMS beach as can be clearly seen from Figure 1.2.1c on the eastern side of the harbor and Figure 1.2.1d for west side of the harbor located inside the Institute. Selection of the proper nesting site is one of the most important factors directly affecting the success of nest and hatchlings [217]. With an increase in offspring survival, fitness for parents also increases [218]. Internal physiology and external environmental parameters govern the site selection strategy of turtles. It has been demonstrated that prior to nesting site selection, adult females coming ashore to nest press their heads into the sand to control suitable environmental characteristics of the area such as moisture, temperature or salinity [79]. The critical features of a nesting site can be summarized as; easy accessibility to the beach, nest placement at a height suitable for avoiding tidal inundation, sand properties show sufficient cohesion for building a nest and to ease gas diffusion and specific temperatures for proper maturation of the egg [219]. The order of importance was classified as critical distance from the sea to avoid inundation or erosion and egg dessication, disorientation or hatchling predation [220]. The opposing pressures of intermediate distances from the high tide water line was thought to be a helpful cue for site preference of the nesting females [221]. Defined environmental requirements for embryo development were small temperature variations, high humidity, low salinity and good ventilation to allow gas exchange between the embryo and the surrounding environment.

For the hatchlings, the preconditions of low predation rates and proper currents for first crawling into the sea were found to increase survival [217].

a b

c d

Figure 1.2-1 Human disturbance on neighbouring beaches of METU-IMS and no human disturbance on METU-IMS Beach taken by the author of this study

a) Human disturbance on eastern border Kocahasanli (KOCA Subregion)

b) Human disturbance on eastern border Limonlu (LIM2 subregion)

c) No human disturbance on METU-IMS Beach (METU subregion)

d) No human disturbance on METU-IMS Beach (LIM1 subregion)

Considering all these findings the most important characteristics of the nesting beaches like beach slope, width and length, vegetation, river and/or estuary presence, timing, sand temperature, sand moisture, sand compaction, sand particle size and mineral content, human disturbance and pollution and natural processes must be determined before the nesting season to achieve high success rates and for conservational monitoring.

1.2.3 Future Work Aimed at Tracking Studies on Sea Turtles

As turtle spending most of their time under water it is hard to identify the foraging habitats, migratory corridors and internesting areas of the females which are fundamental if we are to achieve successful conservation and/or management programs. Some of the generalized techniques which have been used are: observations with snorkel or SCUBA gear searching for both resident turtles and biotic, abiotic characteristics like the existence of algae, corals, flora and fauna which could be used as indicators of potential foraging areas. With a knowledge of the feeding patterns of sea turtles and the dominant prey items around the area it is easier to show the potential. Aerial photos and marine resource atlases may help to identify important areas. To be more confident linear transects could be employed for rapid assessment of potential areas. Ecological data including water temperature, current flows, depth and obvious geological structure could also give clues about the potential of the places. In-water studies like capture-recapture methods can provide insight into the distribution, abundance and size classes [222].

1.3 Outline of the Thesis

In order to meet the objectives stated above, this thesis is organized into four chapters. In Chapter I, some background information related to the concerned topic, summary of literature and the major objectives of this thesis are given. In Chapter II at detailed explanation of the methodology followed is given with a description of the study area. In Chapter III, the results are given. Chapter IV discusses all results obtained from observations, measurements and analysis.

CHAPTER 2

MATERIALS AND METHODS

In this chapter, firstly the study area will be defined mainly by its geographical aspects. Subdivision of the nesting beach is outlined. Throughout the study intense multidisciplinary fieldwork specified for the major aims will be explained in the order of occurrence. To begin with, the importance of the region for the sea turtles will be emphasized by the ecological characteristics of the beach due to the fact that ecological- physical recognition of the study area is important to specify the most appropriate monitoring field methodology. The nesting beach characterization process will be detailed by the aspects of boundary parameter, beach elevation, beach width, sand softness, sand composition, sea defenses, vegetation, predation risk, beachfront lighting and general observation. Secondly, the monitoring throughout the nesting season will be examined mainly under the topic of nesting activity. The literature survey was performed by covering the related articles, reports, journals, books, theses and internet database (Web of Science, Ebsco Host, JSTOR, and PubMed). In this section the commonly used methodology will be divided into two time periods. The first period covers the beginning of the egg laying process until the end of the incubation period. The successive period covers the time period from emergence of the first hatchling and end with the controlled nest excavations. In addition a new automated infrared camera- laser beam alarm system is introduced as an alternative monitoring system. Thirdly, stranding activities and the action plan for when an injured or dead sea turtle is sighted will be given. Details on how genetic samples were obtained and the stages of production of a tracking device to mainly observe the feeding and wintering areas of turtles and the collection of related to their physical environment will be explained.

2.1 Determination of Study Area Suitability

In this section, firstly the study region will be defined. The basic concepts on the study site subdivision and the characteristics of each division will then be given briefly. Later, information on the need for and protocol of the nesting beach characterization study will be summarized. Finally the stages of the insect study critical for sand dunes will be given.

2.1.1 Definition of Study Area

The main study area is located at the Institute of Marine Sciences, Middle East Technical University (METI-IMS) The Institute's campus is located near Erdemli approximately 40 km west of the city of Mersin in southern Turkey which is on the northeastern Levantine Basin (northeastern Mediterranean) as seen in Figure 2.1-1.

Figure 2.1-1 Location of METU-IMS [223]

In order to protect and preserve the marine biodiversity, in addition to research carried out in various scientific fields, and for a constant and progressive understanding of the environment, a marine reserve in front of the campus area, that extends for 500 m offshore and 1400 m along the coastline has been established; the shortest stretch of coastline is 200 m and 800 m. Total distance of the study field, starting from Lamas River in the west and continuing in an eastward direction till the end of the public beach at Kocahasanli "Su Beach", is 3 km. In Figure 2.1-2 while the green lines represent to the area belonging to METU-IMS, blue lines represent the public places studied in 2013. While the beach at the Institute is mainly used by the conscious faculty members living on campus socially and for academic research purposes, the beaches bordering the campus perimeter are used by the general public for fishing and touristic activities. This monitoring study focused on the sea turtles nesting on METU-IMS beach which is protected. But the extensive usage of adjacent areas provided the opportunity to compare the beaches to understand how human usage impacts the nesting behaviour of the turtles. The study area was divided into four sections as; Limonlu 2 (L2) (about 600 m long), Limonlu 1 (L1) (about 200 m long), METU (about 800 m long) and Kocahasanli 1 (K1) (about 600 m long).

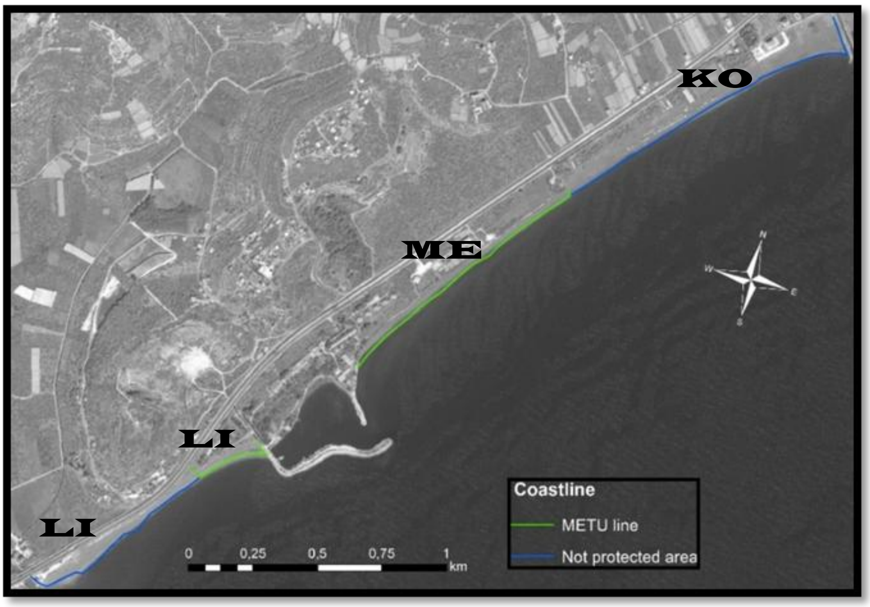


Figure 2.1-2 Study Area

This division was carried out to simplify the beach monitoring due to differences between the sections with respect to human activity, sand composition and settlement. The Institute's beach is divided by the harbor belonging to the METU-IMS used as mooring site for the research vessels. This harbour also has a small beach (around 400 m in length) used by Nile Turtles as a basking and feeding area in the summertime. The area east of the harbour is named as METU in this study bordered by KOCA used as a public beach and camping site in the summer season, while the area west of the harbor named as LIM1 within the campus perimeter including the inhibited fishing zone. The area from the Institute's border (LIM1) reaching to the Lamas River is named LIM2. This is a public beach used by local people and native tourists and by fishermen at a distance of 500 m from the harbour.

2.1.2 Ecological Characteristics of Study Area

Long-term concerns about the ability of coastal sandy beaches to sustain sea turtle nesting are confounded by a general lack of understanding of what characteristics are important to sea turtles during the nest site selection process. From a global climate change perspective, understanding how vulnerable these characteristics are to, for example, sea level rise is vital to sea turtle management and policy decisions, land use planning, and so on. The objective of this study was to develop a methodology for evaluating the vulnerability of sea turtle nesting beaches to climate change forming the basis of this sea turtle nesting beach characterization to monitor how changing coastlines affect bio-diversity and beaches, with a focus on loggerhead and green sea turtles. With this motivation following pre-requisites of the Nesting Beach Characterization Manual [224] the characteristics of METU-IMS were identified and a time-lapse photography program was initialized for long term monitoring of water movement in the tidal zone.

2.1.2.1 Ecological Characterization

Human activity along the coast leads to pressures from factors such as population growth, industrialization, and resource exploitation, leaving shorelines more susceptible to extreme weather events [225]. As human populations increase along the coast, so does the potential for coastline change and its impact on human settlement and investment. While the need to monitor coastline processes has long been understood, most such efforts have been primarily in regard to the endangerment of man-made habitation and investment. Historically, records on changing coastlines have been created by using mapping techniques such as surveys, permanent fixed markers, and aerial photography. Most such methods require a fairly high level of expertise and often substantial costs. On the other side, with the advent of inexpensive GPS systems, costs are much lower, but may still require expertise. Climate change, which is predicted to bring a rise in sea level and stronger storms [226], presents a unique challenge for this species which relies for egg-laying on sandy beaches [55]. Standardized methods for assessing the physical features of loggerhead and green turtle nesting habitats and how changes to these habitats may affect reproductive success are necessary for subsequent conservation and management strategy development. The following parameters relevant to sea turtle nest site selection, were used to characterize METU zone of METU- IMS Beach:

Boundary Parameters; were defined by the nearest built structures at the landward edge of a sandy beach.

Beach Profiles tracked erosion and accretion patterns on the beach with respect to the boundary parameter revealing beach topography over time, were used to calculate beach elevation and beach width. The aim of studying the beach profile was to determine characteristics that may affect the nest selection process such as beach slope or length. The profile was measured from the vegetation line to the LWL (low water line), taking into account the nesting site and the HWL (high water line) in between.

Beach profile survey was done by using the measurement device “Nivo” and the barcoded staff “Mira” as seen inFigure 2.1-3.

Figure 2.1-3 Devices needed to undertake the beach profiling survey and their usage in the field

Measurements were undertaken by first placing the Nivo on permanent stations, which were pre-defined and marked with painted sticks. Permanent station points were set by GPS coordinates. 8 transects lines perpendicular to the shoreline were located such that station 1 was situated in the western most part of the beach and the station number increased in an eastward direction.

Each of the neighbouring transect lines were divided at distances of 100 m as illustrated Figure 2.1-4.

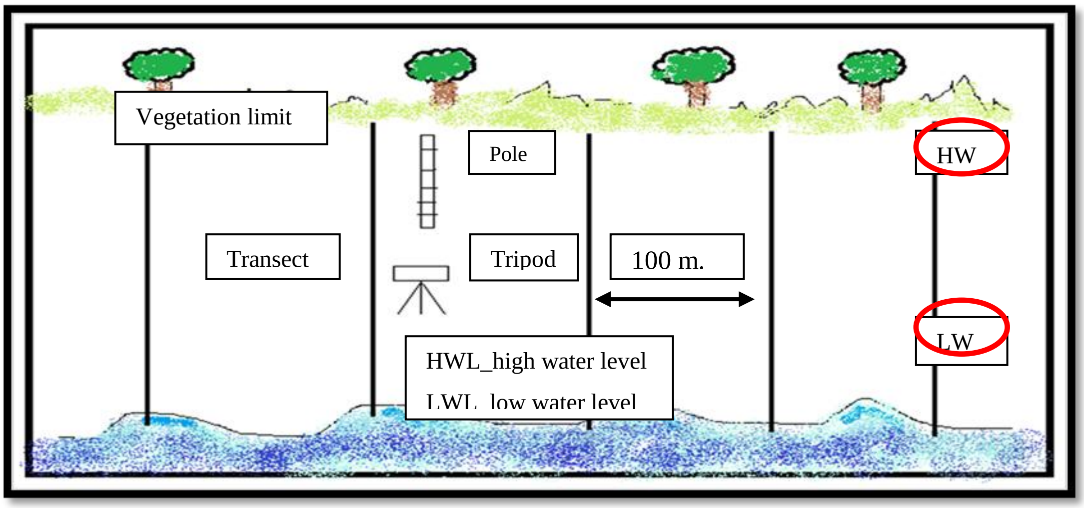


Figure 2.1-4 Illustration of beach profiling methodology

Figure 2.1-5 shows all the stations also measured with Google Earth tools whilst red lines demonstrate the nesting area borders and yellow lines the 100 meter intervals for each transect. Nivo took measurements at different points as point id, height, distance, delta-height and delta-distance. These point ID's which can be extracted as a spreadsheet were given to every single measurement. Measurement points on the transect lines were chosen according to the beginning and the end regions of the beach sections. Vegetation limit, nesting site, dry, semi-wet, wet regions were indicated specifically to show them on the profile. The following parameters are used for study area characterization: Sand Softness: as an important parameter, sand has to have sufficient softness and depth to enable egg chamber excavation [219]. Softness can be identified by digging a 50 cm hole to confirm adequate substrate depth [227]. The level of difficulty experienced gives the following ranks:

High difficulty: unable to dig to a depth of 50 cm with a diameter of 10 cm due to the tough nature of the substrate or obstacles such as gravel, cement or rock.

Medium difficulty: can be dug to 50 cm depth, but with a struggle to do so.

Low difficulty: can be dug to 50 cm depth with relative ease.

Sand Composition: Color, size, shape and sorting of sand could reveal origin, wave strength, and wave movement [228].

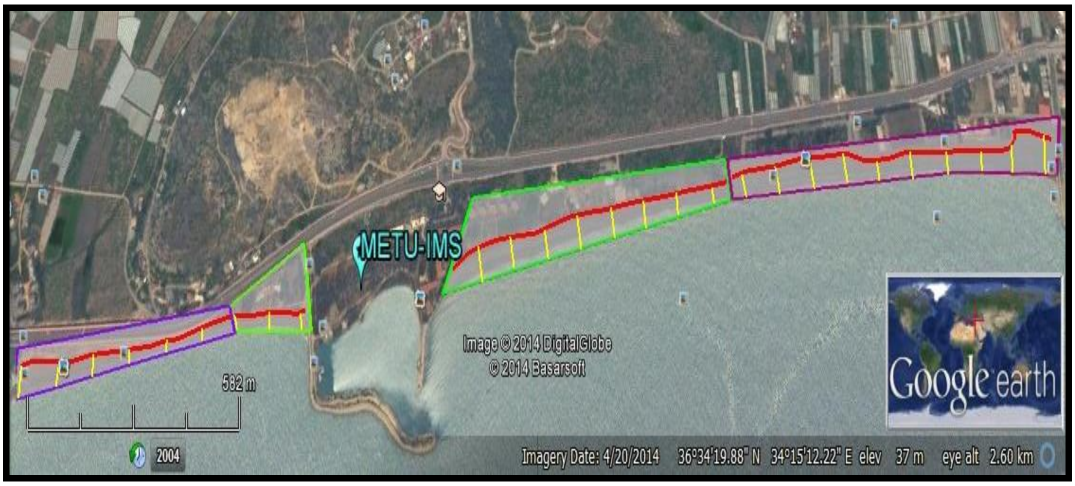
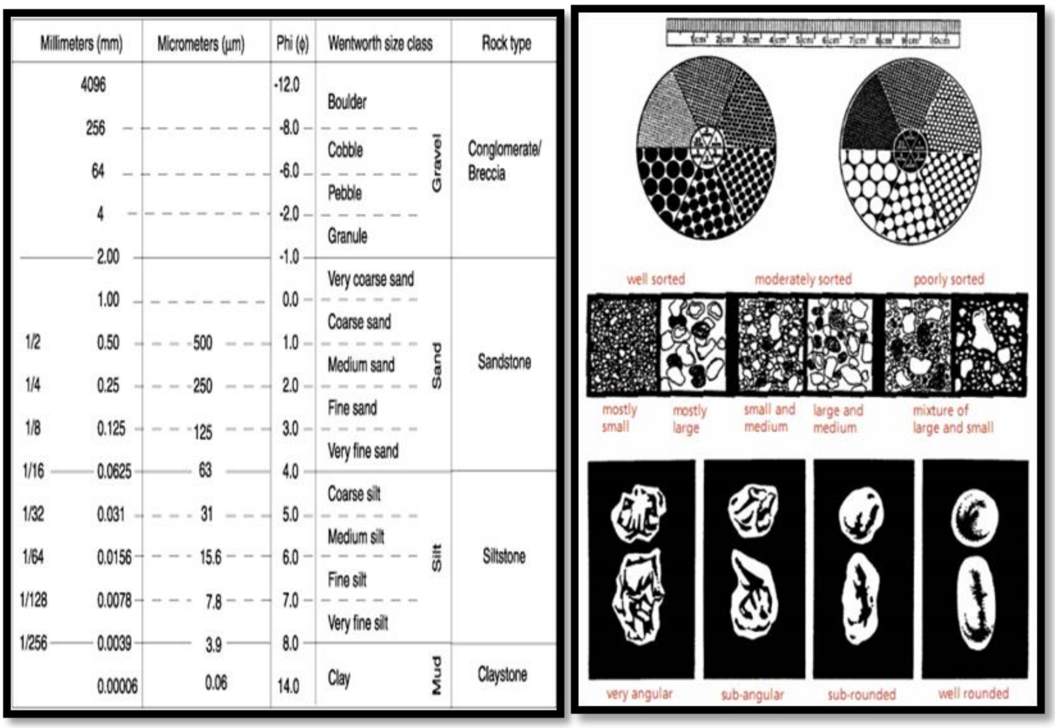


Figure 2.1-5 Profile Stations

The differences in sediment type may reveal whether a beach has been nourished with a different sediment type, or if soil for vegetation has been added. Grain Size Analysis with dry sieving was performed for all the transect samples. Three different points were chosen on the transect lines in order to analyze the grain size. Samples were taken from high tide zone, semi wet zone (5 cm below the wet surface) and the dry region (30 cm below the wet surface). Grain size analysis was done as follows. After establishing the weight of the empty petri dishes (W_{tare}) they were measured after the addition of a wet sample of approximately 50 gr (W_{wet}). All samples were dried in Nuve FN500 at 110 ºC for 24 hours as shown in Figure 2.1-6. The weight of the dry samples was measured again (W_{dry}). Since the tare weights of the petry dishes were known, net weights of the dry samples were calculated by subtracting the Wtare from the total weight of the dry sample. A set of sieves (2 mm, 1 mm, 500 µm, 250 µm, 125 µm and 63 µm) were used to allocate samples. The sieving procedure took approximately 2 minutes by using a sieve shaker. The weight of each group was measured separately. Hence, sample weights were normalized by dividing each sample with total dry weight of the sample. The ratios represent the fraction of very coarse, coarse, medium, fine and very fine sand size groups respectively. According to the Udden- Wentworth grain size classification scheme, the particle sizes can be sorted in different classes. Shape and sorting were determined due to microscopic examination of each samples. To rank the samples, sorting and identification cards used are given in Figure 2.1-7 [224]

Figure 2.1-6 Preparation of samples for size analysis



a b

Figure 2.1-7 a) Udden- Wentworth Grain Size Classification Scheme

b) Sand Sorting and Identification Card [224]

Based on the scheme above, the range of sizes is given in Table 2.1-1.

Table 2.1-1 Grain size classification range used for this study

Particle size	**Class**
2 mm	Very coarse sand
1 mm	Coarse sand
500 µm	Medium sand
250 µm	Fine sand
125 µm	Very fine sand
63 µm	Coarse silt

Vegetation: indicating beach stability and a more predictable temperature regime, the latter being a key variable in temperature dependent sex determination. Documenting plant succession through measuring the distance from the seaward line of permanent vegetation to the high water mark, and any changes in type and condition of vegetation present, provides a useful index of habitat quality.

Predation Risk: Crabs (e.g., *Gecarcinus ruricola*, *Ocypode quadrata*) prey on sea turtle hatchlings and can be a hindrance as the hatchlings journey to the sea; crabs have been known to attack as many as 60% of nests in a single nesting season [224] .

2.1.2.2 Insect Survey

This survey was done for the study site METU to understand the insect biodiversity of the region and their distribution along the zones to link their impact on the sand dunes intensely used by nesting turtles.

Figure 2.1-8 Example of the pitfall covered by vegetation and placed in the sand or soil

The Insect Survey took place on the Sand dunes on the 19th June 2013. The traps were set on the same day from 18:00 to 21:00. Each of thesix sand dunes representing five different biological zones were sampled which included: Wet sand, Dry sand, Vegetation 1 (*Pancratium maritimum*), Vegetation 2 (*Salsola kali*) and Bushes (vegetation occurring at 50cm and above).The survey was conducted on sand dunes, pitfall traps (0.15 litre capacity plastic cups) were placed in the sand or soil by digging a hole with a small shovel and covering with a wooden material or vegetation used for trapping invertebrates shown in Fig. 2.1-8 [229] [230] [231]. In this experiment each sample had 5 different biological zones in which cups were placed. The distance from each pitfall trap located in wet sand, dry sand, vegetation 1, vegetation 2 and bushes was measured from the sea towards sand dunes, whereby the distance from one zone to another varied, due to sand dune formation. Samples were spaced 100 meters apart along the beach as seen in Fig. 2.1-9.

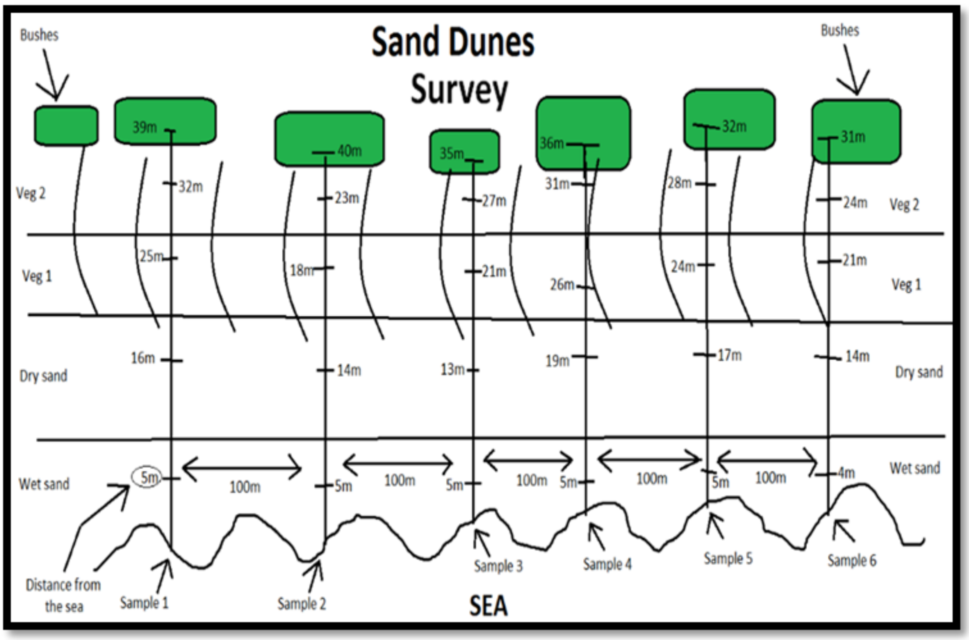


Figure 2.1-9 Study Design prepared by the author of this study

Pitfall traps are one of the easiest methods for sampling terrestrial arthropods on sand dunes [232]. Across the 6 sample sites 30 cups were positioned in total and the samples were collected two days later on 21st June 2013. To calculate the number of species and number of individuals from each cup, very small sieves were used to separate sand and soil from the organisms (invertebrates) which had been collected. The specimens were placed in 70% ethanol and identified. For data analysis at microscope and camera (Nikon D7000) were used to identify invertebrate species. The data was stored on an Excel spreadsheet. To measure and estimate size of insects milimetric paper was used. To determine precise location co-ordinates for the traps GPS Data was collected. To identify the abundances and similarity of invertebrate communities between samples and within sample zones the program “Primer 6” was used for analyses. Several factors labelled Indirect and Direct need to be considered which could impact the survey. Indirect factors: High tide could flood every cup located on the wet sand and possibly on the dry sand too. Rain may affect samples by cups becoming filled resulting in invertebrates drowning or escaping. Similarly, wind can impact samples since cups become filled with sand aiding escape of the insect. Predators could easily consume organisms trapped in cups. Such predators are: foxes, dogs, cats, birds and small reptiles. The sea turtles themselves, nesting on the sand dunes may cause damage to the cups. Direct factors relate to behaviour of members of the public on the beach e.g. removal of the cups through curiosity or children damaging the cups when playing. Rain may affect samples by cups becoming filled resulting in invertebrates drowning or escaping. Similarly, wind can impact samples since cups become filled with sand and it would be easier for the insect to escape from the trap. Predators could easily consume organisms which were trapped in cups. The predators which could eat invertebrates are: foxes, dogs, cats, birds and small reptiles. Also in Turkey some large reptiles like sea turtles are nesting on the sand dunes and is possible they can damage the cups placed in the sand. On the other hand, direct factors include the conditions that when members of the public come and spend time on the beach they may wonder what is the experiment and may damage the samples by removing the cups or destroyed the sample for example children.

2.2 Nesting Activities

These activities encompass the entire breeding season; starting just before the arrival of the first turtle to spawn and ending with controlled excavations after the emergence of the hatchlings. Monitoring studies were dually performed by the regular patrol survey and with the automized camera- laser beam system trial. In order to test the efficiency of the automatized camera-laser beam system daily patrols were done by walking regularly. Field studies were grouped under three main headings; nesting activities, stranding activities and genetic activities. Firstly, nesting activities include data on the turtles coming ashore, the incubation period, the emergence of hatchlings and controlled nest excavations. Pre-season nesting beach preparation began in the first week of May. Day-time patrols were conducted to observe the initial turtle tracks in order to understand when to begin night patrols. Following observation of the first turtle tracks of the season, three to five people monitored the beaches every night until early October. Secondly, stranding activities focused on non-nesting turtles that had come ashore either sick, injured or dead. Lastly, genetic activities are related to analyses which were performed on samples taken from dead turtles.

2.2.1 Patrol Studies

The aim of the beach monitoring was twofold; firstly to count and record all adult female emergences and classify according to track morphology and secondly to locate hatching nests by following tracks of hatchlings. A protocol signed by the Ministry of Forestry and Water Management was followed as a field guide. The patrol studies were divided into two periods mainly due to differences in the turtle's life stages, workload and data collection methods. The first period covers the studies from first arrival of the adult female turtle till the end of incubation. The second period covers the studies on eggs and hatchlings beginning with the first hatchling and ending with controlled excavation.

Arrival of the adult females

This part of field work included daily night patrols which continued till the early morning to facilitate the low sun angle casting a deep shadow behind the tracks making them clearly visible. The total nesting and non-nesting emergences were recorded. During the walks, the most obvious clue showing where the turtles had come ashore were the tracks they had left. Moreover, the symmetry of tracks was taken into consideration while determining the species [14]. Apon discovery of tracks it was firstly determined whether the turtle was still on the beach or had returned to the sea. Each one of these situations needs different approaches to data collection. How to define the tracks is explained in the introduction chapter under the topic of nesting behavior.In Figure 2.2-1 the procedure followed during the first part of the patrolling activity is summarized. When such tracks are seen, the first action is to observe whether there are two sets of tracks (out of the water and back towards the water) or only one set (leaving the water), from which it can be understood if the turtle is still on land, and proceed accordingly.

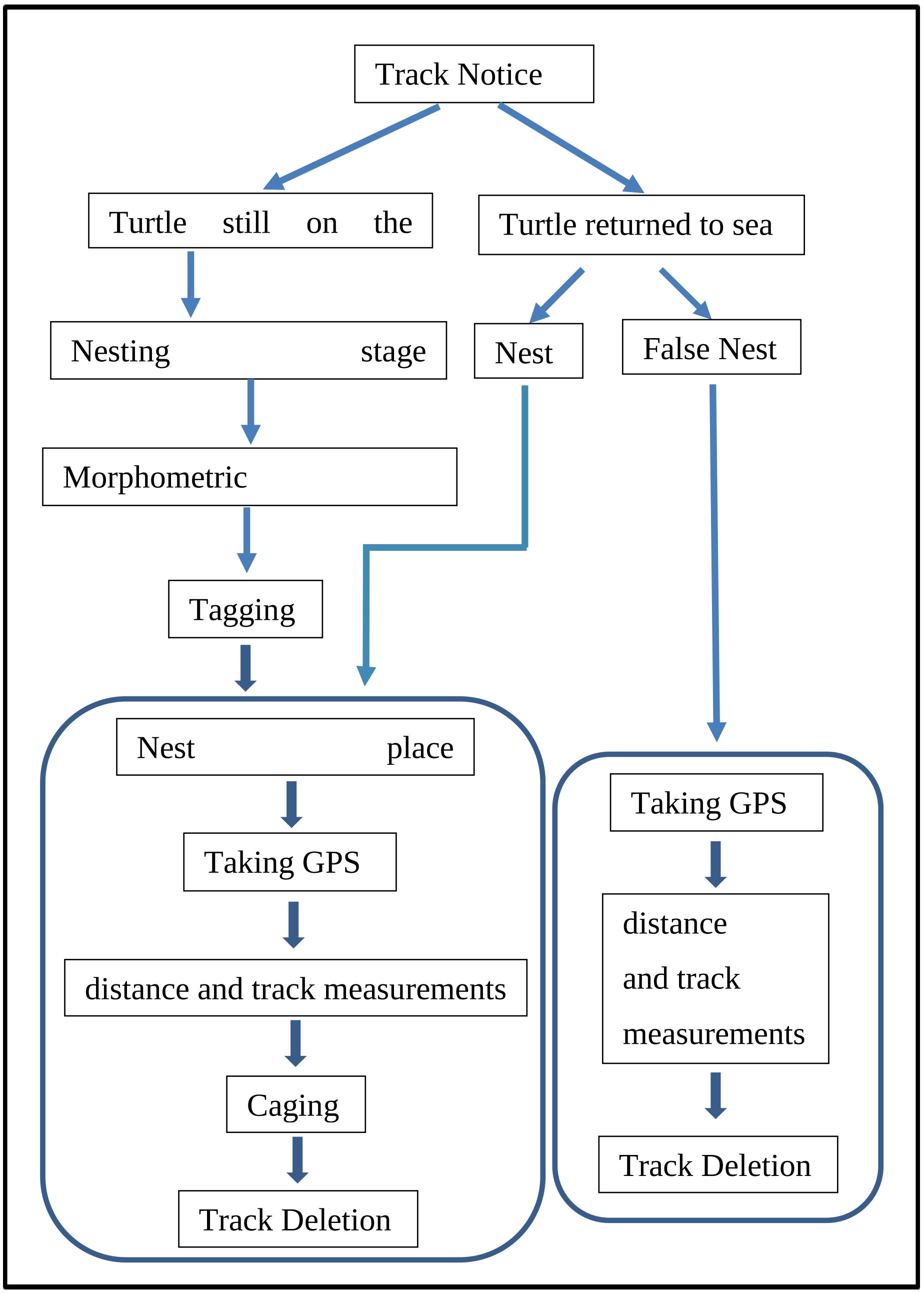


Figure 2.2-1 Steps of Patrolling Procedure prepared by the author of this study

One set of tracks, suggesting that the turtle might still be on land, needs careful approach to understand the stage of the female. This must be done by the most experienced researcher in the group in order to protect the turtle against disturbances. If the turtle is present it is important to determine which stage the turtle is. These stages are defined in the introduction. Until the end of the egg laying process, the researcher must wait kneeling behind the turtle while any others in the group wait at the high tide line. After the egg laying process the group are able to approach carefully from behind the the turtle with absolutely no light source. No-one is allowed to stand in front of the turtles and no touching of their tails and cloacae is permitted due to their sensivity. Tagging and measuring can be done after the turtle has laid her eggs. In this study metal tags provided by the General Directorate of Nature Conservation and National Parks as a unit of the Ministry of Forestry and Water Affairs which are a relatively cheap option compared to expensive micro-chipping techniques or satellite transmitters, were used. Each tag has two letters and four numbers as shown in Figure 2.2-2. The first two letter on the tag represents the nation to which the tag belongs whilst the remaining numbers form the specific identity number of the tagged turtle. These tags provide the information on species, individual turtle, internesting period and migration routes

Figure 2.2-2 Metal Flipper Tags provided by Ministry of Forestry and Water Affairs

At the beginning Turtles are examined for the presence of a tag and existing tag numbers are recorded. If no tag is present, the area of the flipper must be cleaned with alcohol to apply already cleaned tags supplied by the ministry. As with tagging, it is better to obtain morphometric measurements after egg laying to prevent the turtle from distress. Tag attachment must allow for growth and activity of the turtle but be secure enough not to fall out. The curved carapace length and straight carapace length are measured by using tape measure (150 cm) and large calipers (150cm) as shown in Figures 2.2-3 and 2.2-4. The width is widest part of the carapace perpendicular to the midline of the body passing through head to tail. The length along the midline starts with the joint area of skin and carapace behind the head and ends with the notch of the carapace.These are apon collection of all the data obtained directly from the nesting turtle i.e. visual observations, tagging and measuring, researchers must wait until the turtle returns to the sea successfully. On its journey back to the sea, if the turtle becomes disoriented or moves randomly, the use of a flashlight directed on the sand and towards the sea can help the turtle regain the correct course. To compare turtle nest position preferenc es distances of nests from the sea, from dry sand, from semi-dry sand and from vegetation, measurements were taken by using a long tape measure. GPS coordinates were taken to locate the nest. Also the flipper tracks are measured: inner track markings relate to plastron width, outer track markings indicate flipper size. Once data collection is completed all the tracks of the turtle must be removed to distinguish old tracks from fresh ones. When exact position of the nest is determined, presence of eggs is assessed by gently searching for them.

Figure 2.2-3 Straight Carapace Measurements taken by the author of this study

Figure 2.2-4 Curved Carapace Measurements taken by the author of this study

To record the temperature profile inside a nest a temperature recorder, HOBO® Pendant Temperature/Light Data Logger 64K-UA-002-64 was placed into the nest. This device was launched via its software and communications device just before prior to each patrolling in order to adjust data frequency, units of measurements and calibration as can be seen in Figure 2.2-5.

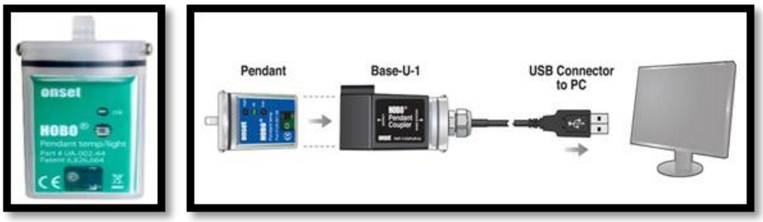


Figure 2.2-5 HOBO® Pendant Temperature/Light Data Logger 64K - UA-002-64 and Data Transfer Interface [233]

Protective cages are placed on top of the nests. In order to direct hatchlings towards the sea three sides of the cages are closed. Each cage is labeled with the following information: date, number of nest and species of turtle as shown in Figure 2.2-6

Figure 2.2-6 Cage placement and labeling taken by the author of this study

The temperature device is hung onto the cage to prevent any damage which could occur when the hatchlings surface and to aid the reading of data. The area around the cage is checked daily for signs of predation. When a turtle is observed on land, the actual egg laying process of egg laying may not occur for a number of reasons. It may be disturbed, make a false crawl or return to the sea without any digging attempt. This could result from of many reasons like; unsuitable location, inappropriate physical conditions of the environment, or disturbance by humans or predators. In such cases all data must be collected as soon as possible without causing further stress or harm to the turtle. All these procedures explained above describes the workload when the turtle is noticed to be still on land by observation of only one set of tracks. Two sets of tracks generally signal that the turtle had already departed but the existence or not of the turtle must still be checked before collecting data. This requires experience on trailing. To begin with, the emerging and returning crawls could be identified by looking for the direction of the sand pushed by turtle as seen in

Figure 2.2-7 [20]. The fresher tracks of the returning crawl are longer and are seen at the tidal zone clearer than the arrival track. Arrows in Figure 2.2-7 show the direction of the nesting turtle's movement.

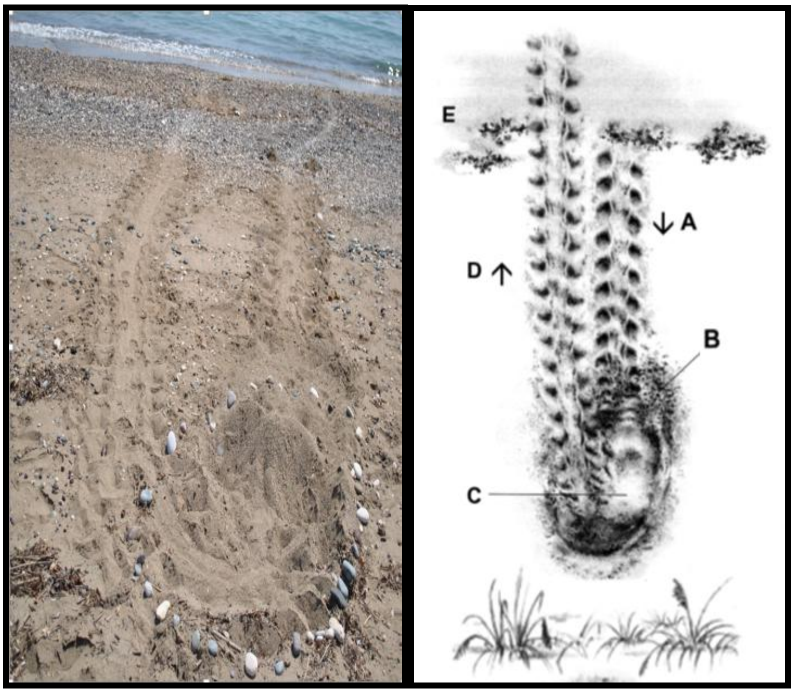


Figure 2.2-7 Illustration [20] and photo of nesting steps of adult female taken by the author of this study

A indicates an emerging crawl understood from the direction of sand pushed by the flipper. Following the path, B represents misted sand over the emerging turtle track. Nesting crawls could be distinguished from false crawls by the structure of the body pits left. While the traces of the primary body pit excavated before the nest chamber in which eggs are deposited are not significant, the secondary body pit is generally made after the egg laying process. C shows a part of the secondary body pit encircled by a crescent shaped cliff left by the front flippers termed an escarpment. D clarifies that the turtle directed back to the sea. The High tide zone seen in E gives the second clue with the help of tidal fluctuations. In the case of false crawls, there could be several patterns which the turtle followed. There may be very little or no sand disturbed, or a wandering turtle may leave the marks of many nesting attempts in her search to find a suitable site. To be sure that the turtle's emergence resulted in nesting the exact position of the eggs must be determined. Using an iron blunt ended T stick helps to understand difference in the resistance of the sand against the force applied. Approximate region where the eggs deposited could be assumed between B and C.Also if the turtle dig the area before with a decrease in the resistance the gap could be felt. In order to prevent destroying eggs the area must be dug by hand till reaching the eggs near the surface. This process may require repetitions to succeed in locating the exact nest position. When a nest is confirmed, the same procedure as for when a nesting turtle is noticed on land is followed. Briefly, GPS data is recorded, distance to sea, vegetation, and dry and semi dry sand are measured in order to locate the nest. Tracks are removed after their size is recorded. As a final step a cage is placed over the nest.

Relocation

Protection of the natural structure of a nesting area and a nest is the baseline of this study. But under certain conditions, in order to increase the hatching success the location of the nest had to be changed. In this study nests were translocated for three different reasons. The first was due to strong public lighting, the more common second reason was that eggs were laid below the average high tide line mark. The third reason was the nest was positioned too close to a rainwater drainage channel. Concerning the importance of the physical environmental parameters for embryonic development, this process must be done with extreme care. In this study, we were able to observe nesting of the female and rapidly assess if there were serious threats due to nest position. All relocation procedures were carried out soon after the eggs were laid. A rigid bucket was used to carry the eggs. While they were taken, we paid attention not to change the exact orientation of the eggs inside the nest. The moist sand was put in the bottom of the bucket then eggs were placed carefully and the top also was protected by moist sand. We concentrated on replicating the original nest parameters namely depth, shape and the order and position of the eggs. Dry sand was removed while the new position of the nest was prepared not to influence airspace between the eggs having importance for their gas exchange. The eggs at the top were also covered by moist sand taken from bottom of the new nest. Even the color of the sand could impact the incubation period. When data on translocated nests were collected, both old and new positions were taken into consideration.

Hatching Activity and Control opening/excavation

After the eggs were laid, nests were protected against predation and checked every day. When the first emergence of hatchlings from a nest was noticed, the incubation period for that nest was calculated. Generally hatchlings appeared at the surface in groups by helping each other. The controlled openings are a necessity for many reasons and the steps are summarized in Figure 2.2-8.

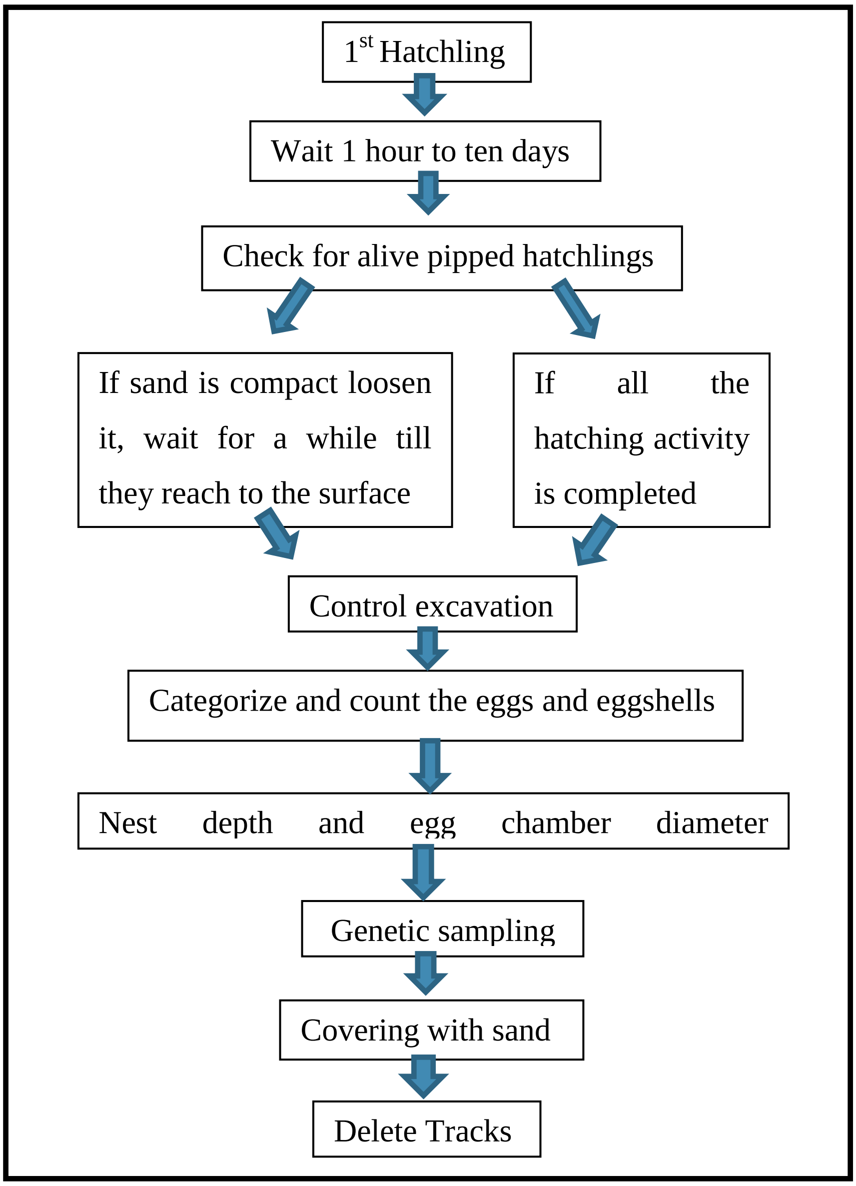


Figure 2.2-8 Steps of the Hatchling time patrol monitoring procedure prepared by the author of this study

The time period from first till last emergence varied from one hour to ten days. Due to the number of nests hatching at similar times excavation of nests opened were completed 72 hours after the first emergence or 80 days after deposition of the eggs.Although there is no specific standardization for time, generally five days was enough time for final eggs to hatch and or weaker hatchlings under risk to be released. The nest must be opened by protecting the original shape of the nest cavity in order to measure diameter of the chamber, the depth from bottom to top and distance to the dry sand. A pocket of sand was taken for humidity measurements. All contents of the nest must be scooped out carefully. Some hatchlings may be entangled in roots or constrained by compacted sand. In such cases, indirect help to free the turtle is preferable. For instance, the roots could be removed or the sand could be loosened instead of directly pulling the hatchlings. Moreover, pipped eggs with live embryos, hatchlings with curled carapaces and hatchlings still attached to the umbilical were sometimes found in the nest. Empty eggshells were placed at the bottom, then covered by moist sand providing a suitable environment and allowing time for the latecomers to emerge. The top of their new nest was filled with moist clean sand and left until they emerged from the nest. For further calculations basically to understand reproductive success data must be collected. Counting yield is important data to calculate hatching success and emergence success. To do so, after the entire nest contents were scooped out and the salvaging process was completed, the eggs were separated into two groups: successful eggs (broken eggshells) and unbroken eggs. Unbroken eggs were categorized as unfertilized and the unfertilized eggs further grouped due to their developmental stages as, early, middle and late embryo. Infected eggs were also recorded. When counting and classification was completed the contents were put back into the nest chamber to become energy source poor dune system.

Tracks of the hatchling tracks may also provide information about nests which were not noticed during the nesting season. In such a situation, the position of the nest must be recorded and species of the turtle must be identified from the hatchlings. Also in the areas where artificial lighting may disorientate the hatchlings, the tracks can be followed to redirect them back towards the sea by holding a light source aimed on the sand for the hatchlings to follow.

2.2.2 Setting-up Automatized Camera-Laser Beam System to Monitor Sea Turtles’ Nesting Season

An automated camera and laser beam system was designed to reduce the work load of patrol studies. This system provides real time data from the beach via phone calls and e-mails. The alarm system is activated by active infrared laser beams and infrared cameras providing barrier systems and used to sense the presence of turtles in the survey area simultaneously. The idea of using an alarm system coupled with active infrared detector laser barriers was based on private home security systems. The Primary alarm system consisted of active infrared detectors and an alarm system. The first trial was done in the 2012 nesting season by using a couple of simple short range active infrared detectors on the METU-IMS beach. A basic alarm system was integrated to this detector. After results showed that the detector and alarm system were successful in sensing any items which passed through the laser beam and alerting the researchers, an upgraded version of the whole system was constructed on the beach for the 2013 nesting season. With a 250 meter outdoor detecting range for each pair of active infrared detectors, three pairs were used to cover the METU sub region. Figure 2.2-9 includes illustration of primary alarm system coupled with active infrared detector. followed by Figure 2.2-10 that illustrating the the connection of alarm system with call center. In brief, when the triplicate infrared laser beam spectrums between active detector sensors interrupted, alarm systems directed the alarm to the call center thar alert the researcher by cell-phone. Detailed features of the active infrared detector laser barriers used in 2013 are summarized in Table 2.2-1, followed by Table 2.2-2 describing features of the alarm system.

a b

Figure 2.2-9 illustration of primary alarm system

a) active infrared detector image taken from [234]
b) alarm system image taken from [235]

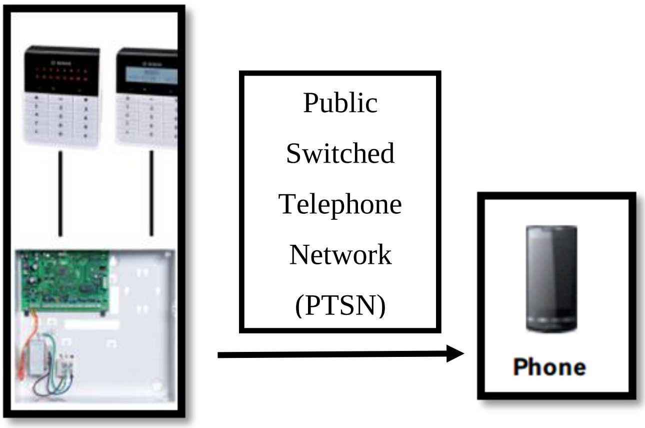


Figure 2.2-10 the connection of alarm system with call center

Table 2.2-1 detailed features of active infrared detector laser barriers

Basic Specification	
Outdoor detecting distance	250 m
Indoor detecting distance	750 m
Beam of light	3 beams
Inducing rate	50~700ms adjustable
Working Principle	Infrared
Beam Numbers	3
Alarm linkage	Yes
Operating voltage	DC10.8-25V
Operating current	≤72mA
Operating temperature	-25°C~55°C
Operating humidity	≤95RH

Table 2.2-2 Detailed features of alarm system

Basic	
PSTN Communicator (Integrated)	Formats: Contact ID, SIA
Magnetic Contacts	recessed, terminal connection, miniature over-head door, surface mount.
Intrusion Detectors	Blue Line, seismic, PIR, TriTech, photoelectric, TriTech PIR Microwave.
Environmental Considerations:	
Relative Humidity	10%-95%
Operating Temperature	-10°C - +55°C
Number of…	
Zones	32
Events	256 history events, stamped with time and date
Wireless Receiver	1
Wireless Devices	32
Cable requirements	four wire, AWG18 or AWG22

Secondary alarm mechanism includes motion sensitive infrared cameras that sent snapshot images taken in the case of any motion to the e-mail addresses giving a noise from the any kind of device can show the mailbox and video recorder. Via wireless internet connection all live recordings could be monitored by any PC. Cameras were set to record when the motion sense feature was activated during the night because of the infrared lights. In addition, the system was also set to take pictures via motion sensors incorporated on the cameras that provided pictures of everything moving on the beach. Pictures and video records were stored by recorder in two hard disks situated in the server surveillance system, located in a cabin in the middle of the beach with internet connection. The camera server was of crucial importance to the recording system because it allow personnel to check in remote control all cameras status and permit to review previously recorded images. This aspect may prove very useful in the case of locating a presumed nest on the beach but detection of the egg chambers is extremely complicated; only after locating the egg chambers can researchers be sure if is a true-nest or a fake-nest. Furthermore, the system sends the pictures to a pre-defined e-mail address where researchers could view and select the photos useful in the monitoring work. With this system, researchers were also able to collect important evidence of the passage of a turtle, determine the species and in the best case understand whether the turtle had already been observed or not. Real time displays were transferred simultaneously to the computers via wireless-internet. But, only the moments when the cameras sense the motion were recorded. Another important result of the motion sensitive feature was an alarm to alert the researchers. Illustrations of cameras and recorder used in this study are given in Figure 2.2-11.

Figure 2.2-11 Illustrations of camera and recorder

The features of the cameras are given in Table 2.2-3 followed by Table 2.2-4 including detailed features of the recorder.

Table 2.2-3 Detailed features of night vision cameras used for determining exact position of sea turtle on land

Features			
Sensor	1/3" SONY CCD	Scanning filed	4.9mm(H)×3.7mm(V)
S/N Ratio	More than 48dB	TV System	PAL / NTSC
Resolution	650 TV Line	Minimum Light Rate	IR ON 0 Lux
Picture Element	PAL: 500(H) ×582(V)	Shutter Speed	PAL: 1/50s ~ 1/100,000s
	NTSC: 510(H) ×492(V)		NTSC: 1/60s ~ 1/100,000s
Gamma Rate	0.45	Auto Gain Control	Auto
Auto White Rate	Auto	Back Light	Auto
Synchronization	Auto	Lens	8 mm.
Visibility	100 Mt.	Power Consumption	DC 12V 3500mA
Power Consumption	DC 12V	Operating Temperature	0 ° +50°
Weight	450 gr	Body	Aluminum Body

Table 2.2-4 Detailed features of recorder

Compression	H.264
OS	Embedded Linux
Video Input	Composite 16 BNC Inputs
Video Output	Composite 1 BNC Outpu (1.0Vp-p, 75 Ohms)
Loop Output	Composite 16 BNC Loop Outputs
Spot Output	Composite 3 BNC Outputs
VGA Output	1 VGA
Display Resolution	1024*768 - 1280*1024 - 1440*900
Recording Resolution	1024*768 - 1280*1024 - 1440*900
Audio Input	RCA 16 Inputs
Audio Output	RCA 2 outputs
Alarm Input	16 (TL, NC/NO Programmable)
Alarm Output	16 (TL, NC/NO Programmable)
USB Port	3x USB 2.0
Recording Quality	D1-HD1-CIF
Recording Mode	Schedule / Alarm / Motion / Emergency
Motion Detection	22 x 15 Grid
Playback Speeed	x1, x2, x4, x8, x16, x32, x64
Archive File Format	EXE / JPEG
GMT Time Zone	Supported
Auto DST	Supported
Primary Storage	Up to 3.0TB 2*1.5
Dimensions	370 (W) x 50 (H) x 325 (D) mm

Eighteen infrared cameras were mounted on nine poles placed at one hundred meter intervals along the METU and LIM1 sub regions. Cameras were set to record every activity on the beach during the night due to the infrared lights. Figure 2.2-12 shows how the placement of the camera system is designed for LIM1 sub region (Figure 2.2-12 a) and for METU sub region (Figure 2.2-12 b) excluding the harbor between these sub regions.

(a) Limonlu (b) METU

Figure 2.2-12 the illustration of designing the locations of the camera coupled poles

Following Figure 2.2-13, illustrates the working principle of the camera-laser system covering interconnecting region of camera coupled on two different poles directed towards each other.

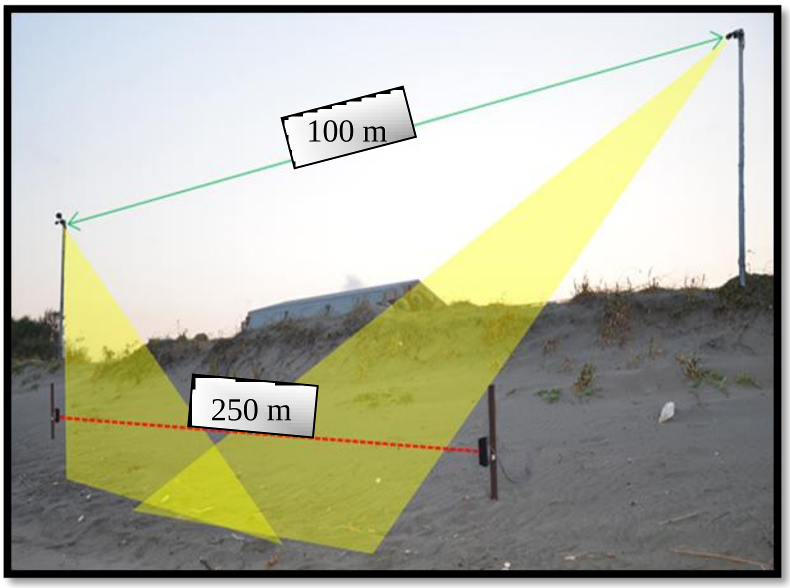


Figure 2.2-13 the illustration showing field of view covered by the camera couple with laser beam

Additionally, to cover a larger area, two more pairs of cameras were mounted on the beach as shown in Figure 2.2-14.

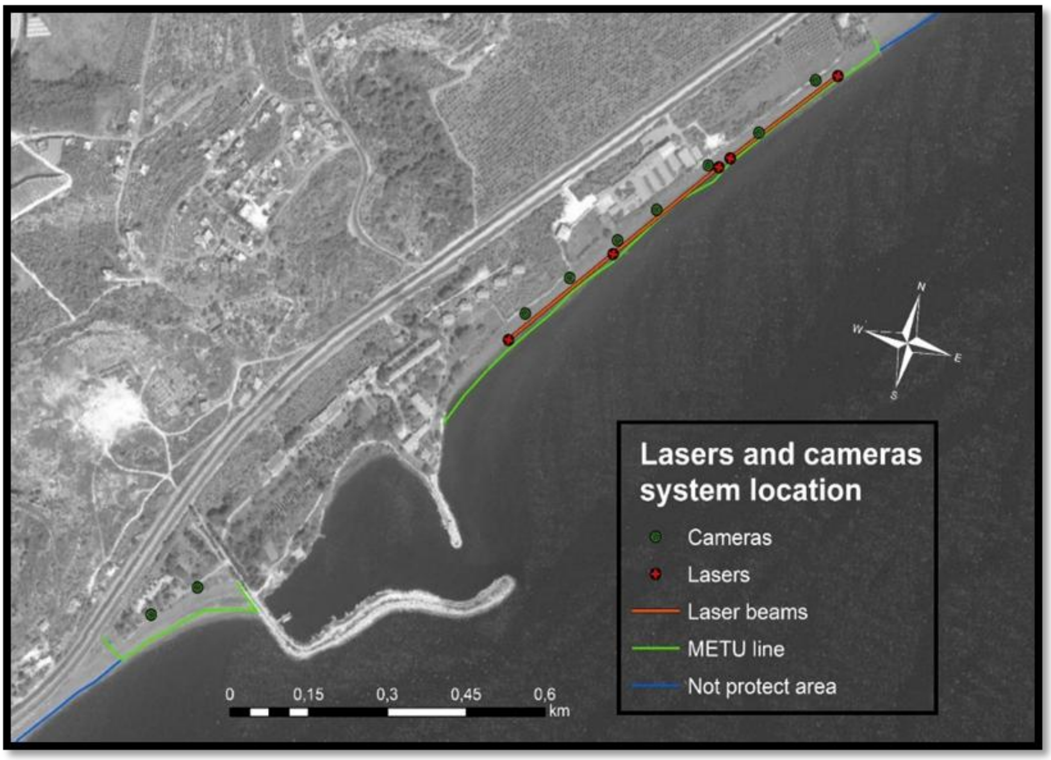


Figure 2.2-14 the illustration of system construction on 2013 nesting season

To summarize, since all the area covered by cameras could monitor any place provided that internet access was available, this undoubtedly did save time. There were two types of alert mechanism coming from laser barriers via the call center and from the camera recorder via e-mails sent when the motion-sensor was activated.

2.3 Studies on Dead Turtle / Stranding Activities

Stranded turtle refers to non-nesting turtle which have either been injured, are sick or dead that have been washed ashore. The work plan for stranding activities is summarized in Figure 2.3 1. Turtles were either found in the study area during patrolling or were reported from outside. For the outside calls, after the condition and exact position of the turtle was determined, the exact position of the turtle was reported to the full time Sea Turtle Rehabilitation Center of Mersin. Moreover, if the turtle was located nearby, researchers from METU- IMS visited the site for initial assessment and to deter public interference.

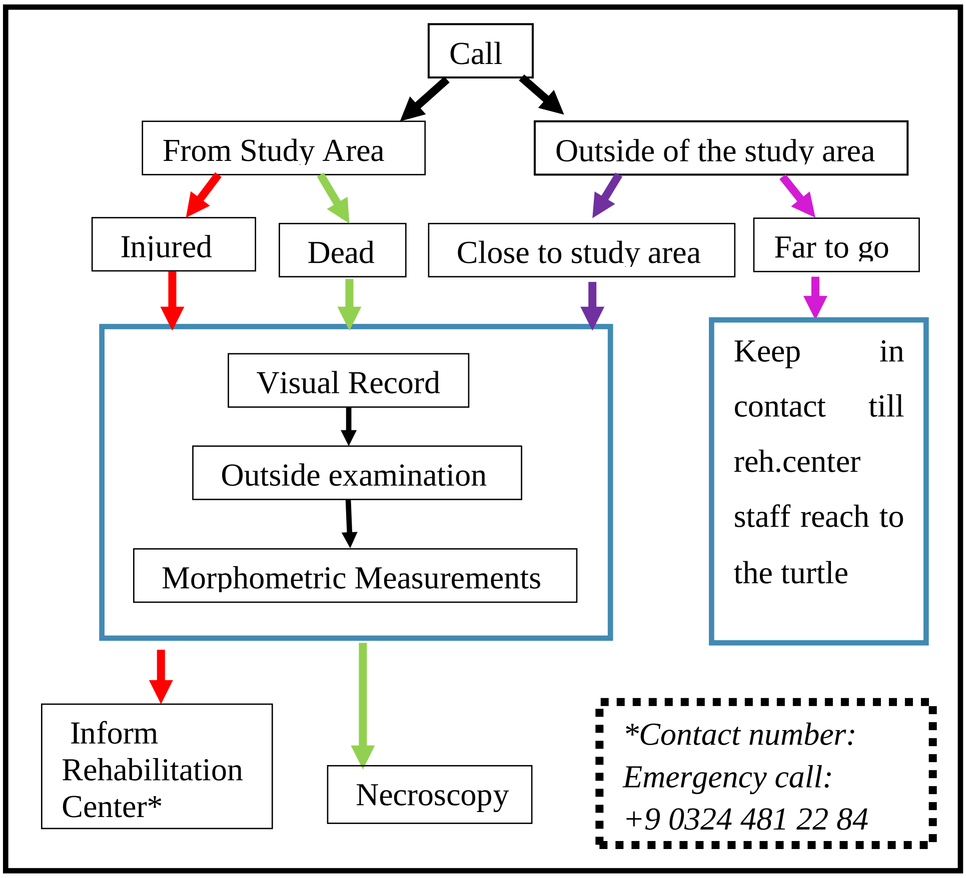


Figure 2.3-1 Stranding Protocol prepared by the author of this study

2.4 Educational Studies

Important quantitative elements of interdisciplinary training in conservation include a working knowledge of basic models and statistical evaluation of data. There is a need to be aware of the value of quantitative analysis as a provider of recommendations that evaluate potential sources of bias and uncertainty and key evidence for motivating conservation action. To promote a broader appreciation for the uses, and potential misuses, of quantitative analysis, universities need to make population-dynamics training more widely accessible to everybody. Throughout this study informative presentations and field activities were applied to different age groups from preschool and primary school children to high- school and undergraduate-graduate students. Moreover, the staff members and families living and on the METU-IMS campus were informed before the beginning of the nesting season to instruct and/or remind them about proper usage of the beach, how to use artificial lights, and being careful with domestic animals.

2.5 Genetics

The commonly used approaches amongst the different methods for DNA barcode identification are grouping sequences using genetic distance in combination with tree building methods [236]. A piece of muscle was taken from two dead *Caretta caretta* samples for DNA isolation. Muscle tissue from each sample was placed separately in a 1.5 ml vial, homogenized and DNA was extracted with 10% 200µl Chelex100 sodium solution (Fluka) at the IMS-METU laboratory. Quality and quantity of the extracted DNA was estimated using a MSP-100 Micro-Spectrophotometer, and DNA was diluted to a final concentration of 10-50 ng/lL. Approximately 700 bp were amplified from the 5' region of the cox1 gene from mitochondrial DNA using universal primer:

f'TCAACYAATCAYAAAGATATYGGCAC,
r'ACTTCYGGGTGRCCRAARAATCA.

The same PCR primers were also used for direct sequencing of the PCR products (Macrogen Inc., Amsterdam) for one direction on each DNA sample (confirming the validity of sequence outcomes). Bio-Rad SsoFast Eva Green supermix was used for PCR amplification. PCR reactions were done with 10 µl total volume, it was consisted 1 µl DNA; 0, 8 µl forward and revers primers; 5 µl ready mix and the rest of volume was completed with molecular grade water. The polymerase chain reaction (PCR) has been done by Roche 480 qPCR at a few steps (pre-incubation, amplification, high resolution melting and cooling). The details of program were given at Table 2.5-1. Sequence data, chromatogram, and primer details for specimens are available within the project file '113Y179 "Karadeniz Zooplanktonunda Hızlı Tür Tayini için bir Yöntem" on the Barcode of Life database site at the University of Guelph [235]. Sequences were aligned using BioEdit v.7.0.9.0 (6/27/07) software. Sequence divergences were calculated using the Kimura two parameter (K2P) distance model [237]. Codon positions included were 1st+2nd+3rd. All positions containing gaps and missing data were eliminated. There were a total of 654 positions in the final dataset. Maximum likelihood (ML) tree of K2P distances were created to provide a graphic representation of the patterning of divergence between species [238]. The three has been created using present and the previous studies samples, which loaded, to BOLD and NCBI database. Bootstrapping was performed in MEGA5 [239] with 1000 replications to observe variation between samples [240] .

Table 2.5-1 Steps of PCR

Program names	Temperature	Time	Cycle number
Pre-incubation	98℃	00:03:00	1
Touchdown	56-95℃	00:00:15- 00:00:35	1
Amplification	95℃ 55℃ 72℃	00:00:15 00:00:35 00:03:20	30
High Resolution Melting	95℃ 40℃ 70℃ 95℃	00:00:01 00:00:05 00:02:00 -	1
Cooling	40℃	∞	1

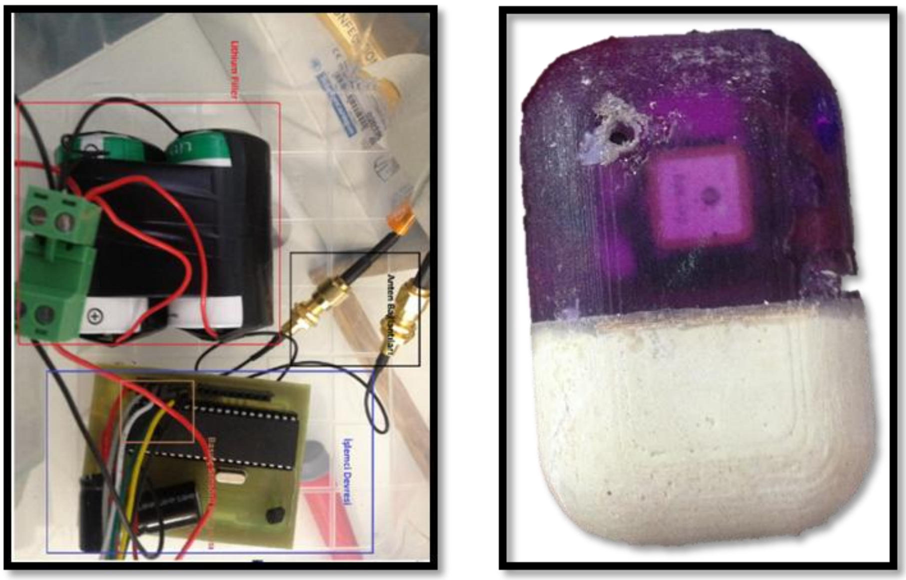
2.6 Tracking Studies

A novel GPS tracking system embedded with a GPRS communication module and pressure and temperature sensors was developed. Primary tests were done and the system continuously developed to supply the best output and optimum conditions for sea turtles. The Tracking system was able to transmit the data by using GPRS antenna. Data packets consist of GPS coordinates depth and temperature information. All data was uploaded to a web site automatically and could be converted to Excel format. A prototype circuit, covered with polymer epoxy, was produced in order to test the underwater durability of the system as seen in Figure 2.6-1.

Figure 2.6-1Depth test prototype circuit

The prototype is submerged to the depths of 25, 50, 100, 125 and 150 meters to test its durability against pressure. A micro controller “16F887” was used, programed by a CCS compiler. GPS/GPRS module, pressure & temperature sensors were connected to an in house micro controller circuit. This circuit was powered by using

Li-SOC12 batteries, especially design for low current level use. These batteries hold 39 Ah at full capacity, approximately fifty times the capacity of commercial batteries shown in Figure 2.6-2.



(a) Before molding (b) After molding

Figure 2.6-2 Tracking system setup before (a) and after (b) molding process

A special elastic bag designed to increase the usage area like soft shelled turtles is seen in Figure 2.6-3. Bonding materials such as special glues can also be used providing harmless attachment to the carapace.

Figure 2.6-3 Elastic carrier bag for alternative attachment

2.7 Data Analyses

The The formulas and main tools used for obtaining and representing data is given in this section beginning with formulas followed by GIS usage to visualize data and with the attempt of creating a common database.

2.7.1 Formulas

Nest Density: number of nests per kilometer.

$$ND = N / D$$

Where *N* is the number of nests and D is the distance.

Nesting Success: Not every emergence results in nesting. The number of successful nesting attempts give the nesting success. The nesting success (NS) percentage is calculated by the formula:

$$NS (\%) = 100 * [(N) / (N+T)]$$

Where *N* is the number of nests and *T* is the number of tracks without successful nesting.

Survivor Nest/ Nest Success (%): Not every nest results in successful hatching, the incubation period which could be disrupted due to inundation, erosion and human disturbance, was computed by dividing the total nest number by the number of nests from which at least one hatchling emerged:

$$\text{Survivor Nest} (\%) = 100 * (S/N)$$

Where *S* is the number of nests that successfully completed incubation (at least one successful hatchling is needed for validation of survival), and *N* is the total number of nests.

Hatchling success (%): Percentage of successful hatchlings in a clutch was calculated by dividing the number of hatchlings which left their eggshells by the total number of eggs.

Incubation Duration: The number of days between the adult female egg laying process and the date of first emergence.

$$I.D = D_{1stH} - D_L$$

Where D_{1stH} is the Day of first hatching and D_L is when the female laid the eggs.

Average Incubation Duration: calculated by the following formula:

$$I.D_{avg} = \sum I.D.. / N$$

Where $I.D_{avg} = \sum I.D.$ is the sum of all incubation durations of all nests and N is the number of nests in total.

Average egg number: Representing the average clutch size for all nesting activities, calculated for both species separately and together by the formula written below:

$$N_{Eavg}: \sum NE / N_n$$

Where $\sum NE$ is the total number of eggs and Nn represents the total number of nests.

Reproductive success can be determined by calculating emergence success and hatching success. Hatching success is often 1% or greater than emergence success [64].

Emergence success: The number of hatchlings that reach the beach surface, is calculated as:

$$(ES-LH-DH)/\ (ES+UE+DE)$$

where, ES is the number of empty shells, LH is the number of live hatchlings, DH is the number of dead hatchlings remaining in the nest chamber, UE is the number of unhatched eggs remaining in the nest, and DE is the number of depredated eggs (nearly complete shells containing egg residue [64].

Hatching Success: The proportion of hatchlings that hatch from their egg shells, is calculated as:

$$(ES)/\ (ES+UH+PE)$$

where ES is the number of empty shells (comprised of an egg > 50%), UH is the number of unhatched eggs remaining in the nest, and PE is the number of piped eggs with dead hatchlings [64].

Statistics were applied to indicate correlation of physical environmental parameters with the nesting and non-nesting emergences and hatching success. All statistical analyses were conducted using SPSS 10.2 package program.

2.7.2 GIS Maps

In the monitoring during summer 2013, as well as collecting important data concerning the morphological characteristics in all specimens observed, the nest characteristics, and finally the analysis and calculation of the hatchlings success rates, it was of extreme importance also to collect all GPS co-ordinates for each nest and the coastline which when combined with the entire data report made it possible to create several maps through GIS (Geographic Information System) by open source or licensed software which accurately showed the nests, fake-nests and no-nests distribution. The data acquired during each patrol could ultimately be directly projected and identified as a point into a map. Usually GIS software provides a background map showing the points of interest represented by geographical coordinates (latitude and longitude). It may seem a simple instrument, but in reality it requires long and laborious work due to the necessity of the program to processes data in its own language, so before providing information, this must be "translated" into GIS language to obtain the desired result. Each daily report was initially transcribed into a single electronic sheet as doc file, in which were recorded all measurements, sightings, descriptions and all GPS coordinates. The software reading system is based on the lecture of a text files (.txt - “text edit” on iOS, “notepad” on Windows) where data must be pasted from excel (.axles) format, so the first step is essentially based on an initial data conversion from the. doc file to an Excel spreadsheet, in which data must be correctly placed on a grid and sorted in chronological order, and where coordinates written in Decimal Minutes and Seconds system, must be converted in Decimal Degree. Each row denotes the corresponding report event with all measurements performed, including the converted coordinate. The parameters used and shown for each corresponding point on the map consist of measurements carried out for nests, fake-nest and no-nest. For every spreadsheet created, the program converts the data provided to data displayed on the map generated, but is not limited to this. If data are entered correctly for each location shown on the map, the program shows whether it is a nest, fake nest, or no nest, as well as all other measurements related to that point. Once all data on the spreadsheet has been transcribed and sorted, for complete and optimal file organization, it's very useful to create additional sheets in the same document where the user can copy only necessary information for a detailed view of the individual categories of interest. In our case the base spreadsheet was created with the total data collected, then with this initial data we were able to create several specific spreadsheets containing only data about the total number of nests, fake-nests and no-nest, as well as sheets detailing only hatched nests with all offspring count data. In addition to these spreadsheets, we included two other spreadsheets displaying about seventy GPS points of the monitored coastline and several landmarks. This will help in the identification of the true coastline, demonstrating the modification of the intertidal zone and receding of the semi-dry sand during the last year. In order to create a new map, additional information must be added from the. txt generated before, for example the total amount of data collected. To allow the software to show the GPS points on a map it needs to be set with a specific geographic coordinates system which is the World Geodetic System elaborated in 1984, which "defines a reference frame for the earth, for use in geodesy and navigation" [National Geospatial- Intelligence Agency website. World Geodetic System section]. After application of these settings all the points appear ordered on a blank page where it is possible to get a first impression about the data distribution. To create a first map it is very useful to add a base-map of satellite imagery, which shows in the background the exact distribution of the data in space for a complete view and fuller comprehension of the map. Users can then modify each field of work by selecting different spreadsheet values, e.g. it is possible to change color, shapes of the points, add scale bars, legends and North Arrow.

CHAPTER 3

RESULTS

In this study, the Results are discussed in the same order as used for the previous chapter “Material and Methods”. The same chronological order will also be used in the Discussion Chapter.

Firstly, the ecological parameters of the study area are presented under two subheadings: ecological characterization and insect survey. The data presented here enables us to identify the study area and to link physical –ecological characteristics of the study field with success of the breeding season.

Secondly, the results of the 2013 season nesting activities are reported under two main sub-headings differing due to the monitoring methodology. The first - monitoring by daily patrols represent the standard data that could be obtained via the commonest methodology of monitoring including the comparison of data from the closest nesting sites to data obtained at METU. In the Discussion chapter, values for the nearest formal nesting sites are also represented. The common methodology results are followed by results obtained from the new monitoring trial coupled with infrared camera and laser beam systems. Reliability of the two different monitoring methodologies is discussed. Secondly, a new automated infrared camera laser beam alarm system is introduced as an alternative monitoring system.

Thirdly, stranding activities and the procedure for when an injured or dead sea turtle is reported is given.

Finally, how genetic samples were taken and the stages for production of a tracking device to mainly observe feeding and wintering area of turtles and collecting data on their physical environment will be explained within the context of future planned work.

3.1 Ecological Characteristics of the Study Area

3.1.1 Ecological Characterization

Boundary Parameters; nearest built structures at the landward edge of the sandy beach are shown as Google Earth images for each sub region. The boundary parameter results of all subregions are summarized in Table 3.1-1.

Table 3.1-1 Boundary Parameters of each sub region

Subregion	**Boundary Parameter (m)**
LIM2	18
LIM1	52
METU	44
KOCA	18

In the images represented in Figure 3.1-1 and Figure 3.1-2 each sub region is defined as a different polygon, and red lines indicate built structures. Moreover, yellow lines represent distance measurements whose values are given in blue boxes. In both figures brown arrows indicate the closest structure to the sea. For Figure 3.1-1 covering LIM2 and LIM1 sub regions, the most invincible red line among all sub regions in LIM2, shows the wall structure along the whole beach ending with Lamas River. At that point a bridge greatly narrows the beach width with only an 18 meter distance to the sea. During the 2013 nesting season there were many fake crawls whereby turtles on encountering the obstacle of the wall immediately returned back to the sea in the LIM2 sub region. On the contrary, all fake crawls in the LIM1 sub-region had at least one body pit showing nesting attempts where the closest structures were 52 meters away from the sea. Figure 3.1-2 covering the METU and KOCA sub regions shows that tents erected in the KOCA sub region were the closest structures at 18 meters distance from the sea. Unfortunately, tents were not the only obstacles for the nesting turtles: a small shop, WC and Showers and indiscriminate usage of the beach resulted in intense artificial lighting and noise. In contrast at the METU sub region which displayed high nesting and hatching success rates, the nearest structure was situated 44 meters from the sea, structures with the next nearest structures at distances of 86m, 94m, 96m and 103 meterstherefore beyond the turtle nesting zone.

Figure 3.1-1 Boundary parameters for LIM2 and LIM1 sub regions

Figure 3.1-2 Boundary parameters for METU and KOCA sub regions

Beach Profiles; based on the boundary parameters, tracked erosion and accretion patterns on the beach revealing beach topography over time. Beach profile study giving beach elevation, slope, lengh and width is beneficial to understand critical characteristics behind the nest selection process. From the profiling study of the study site in 2013 nesting season, the changes in elevation along each transect are summarized in Table 3.1-1. Table 3.1-1 the maximum average distance value (50.8 m) was recorded for the METU sub region with average elevation of 1.2m, followed by the KOCA sub region with similar grain size characteristics and elevation but only when the seasonal camping site on the beach was absent. When the camping site was present at the KOCA sub region, both nesting area and elevation values decreased dramatically. LIM2 and LIM1 sub regions displayed highest values for mean elevation values and a wider range of elevation.

Table 3.1-2 the range of elevation and average elevation values specified for each sub-region

Region	**Number of transects**	**Elev. Range(m)**	**Av. Elevation(m)**	**Av. distance(m)**
LIM2	6	0-9	3.2	33.9
LIM1	3	1-7	4	29.5
METU	8	0-5	1.2	50.8
KOCA	10	0-4	0.8	30.28
KOCA*	10	0-6	1.2	47.71

* indicates the values after the seasonal camping site had closed.

When all profiles are merged into one profile the representation of METU-IMS can be seen in Figure 3.1-4. χ axis shows the distance from the reference point in meters, y axis denotes the elevation values in meters. The division of the regions into shoreline, swash zone, intermediate zone, vegetation and dune was based on thecollective data for each zone.

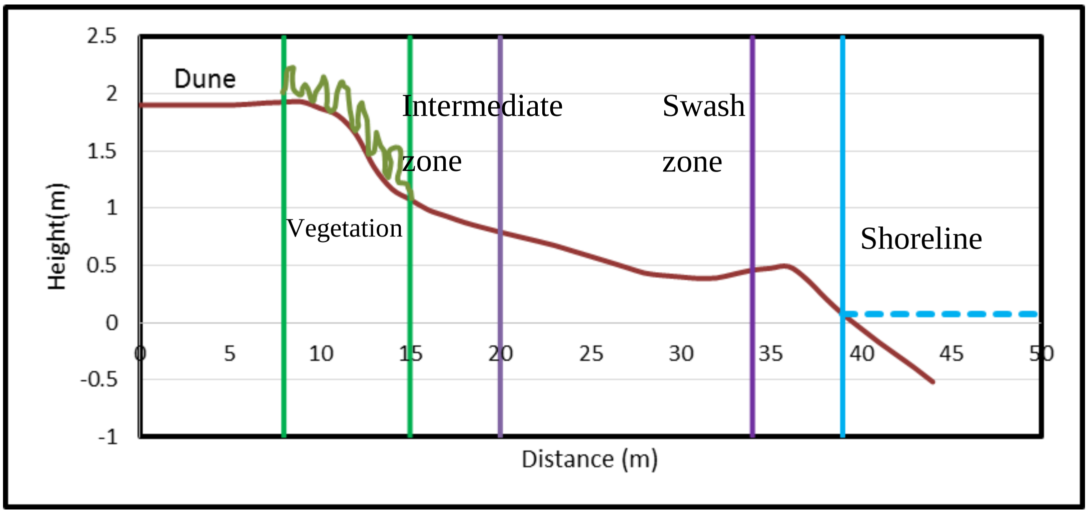


Figure 3.1-3 Beach profile for METU-IMS

Sand Softness

The level of difficulty experienced while digging 50 cm depth hole with a diameter of 10 cm resulted as; high difficulty for LIM2 and LIM1 sub regions, and medium difficulty for METU and KOCA sub regions.

Sand Composition

Sediment type can be evaluated by size classification of grains and by color, size, shape and sorting.

- Grain Size Analysis

Three different points were chosen on each of the transect lines in order to analyze the grain size shown in Figure 3.1-4 for METU sub region and in Figure 3.1-5 for LIM1 sub region. Pie charts give the analyses results as percentages. Samples were taken from the high tide zone, semi wet zone (where 5 cm below the surface is wet) and the dry region (30 cm below the surface is dry).

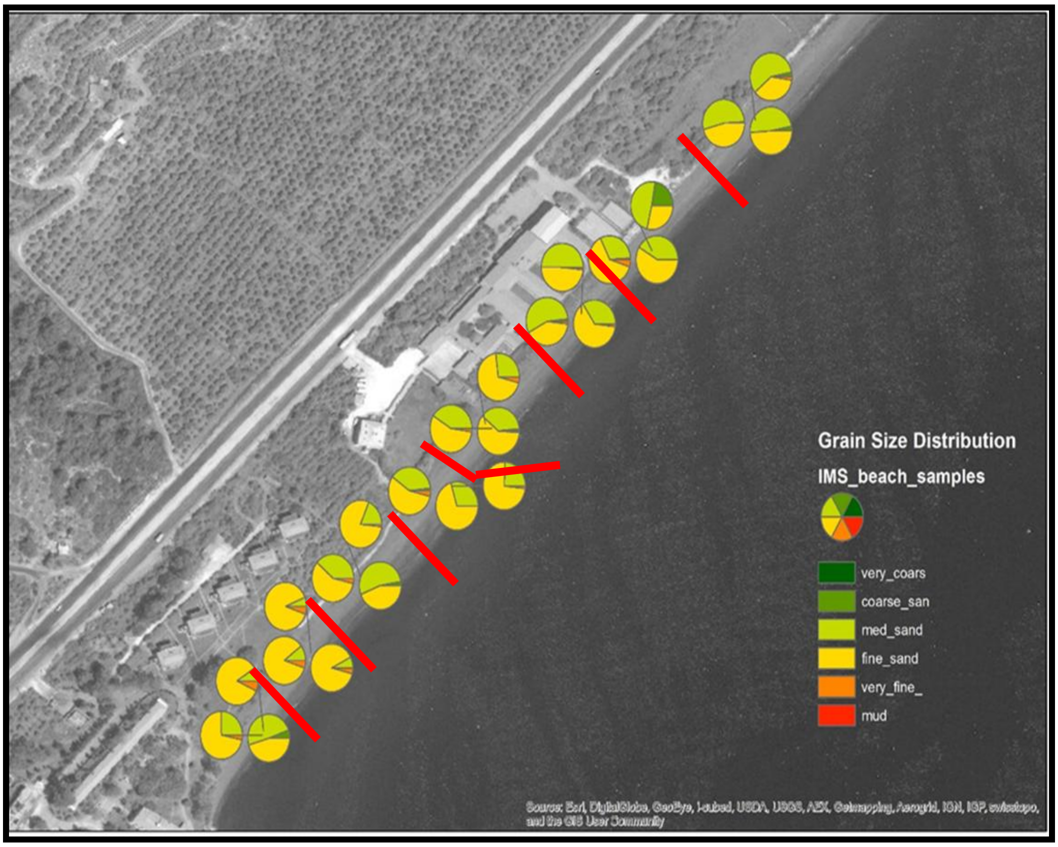


Figure 3.1-4 Grain size classification of three points on each transect along METU sub region

When the results of three points on the same transect had been reduced to one point by taking the average value, the percentages could be simply compared with all transects shown in Figure 3.1-6 in which numbered labels indicate transects from METU sub region from west to east and L1, L2 labels refer transects from LIM1 sub-region from east to west. From Figure 3.1-6 and Table 3.1-3 it can clearly be seen that sand of the LIM1 sub region was bigger in size than METU sub region.

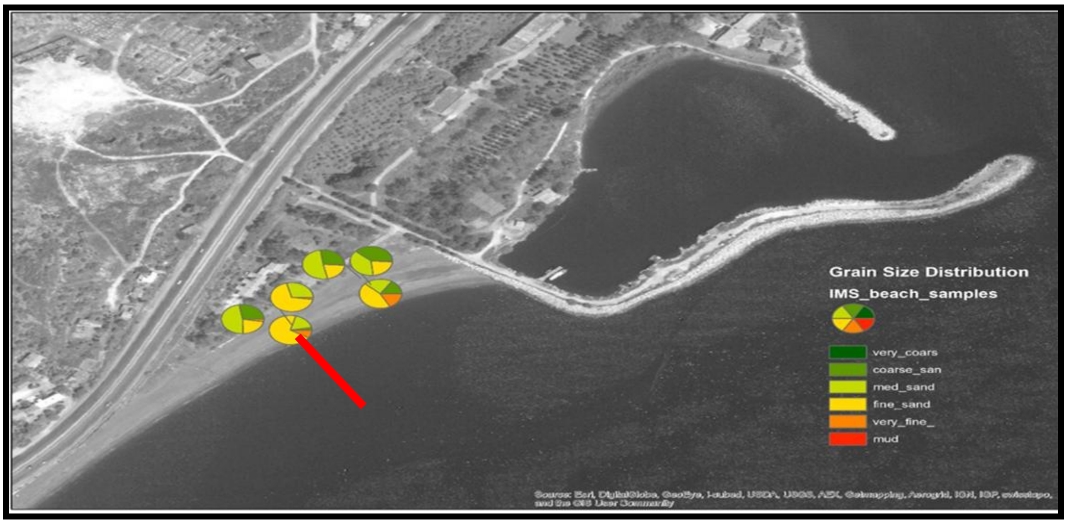


Figure 3.1-5 Grain size classification at three points on each transect along LIM1 sub region

The second result obtained from these analyses shows that size percentage is correlated with distance from the sea, longer distances had higher percentages of bigger particles. Moreover, for METU sub region, mainly composed of a mixture of fine sand and very fine sand, the percentages of the very fine sand decreased while the percentages of the fine sand increased from west to east.

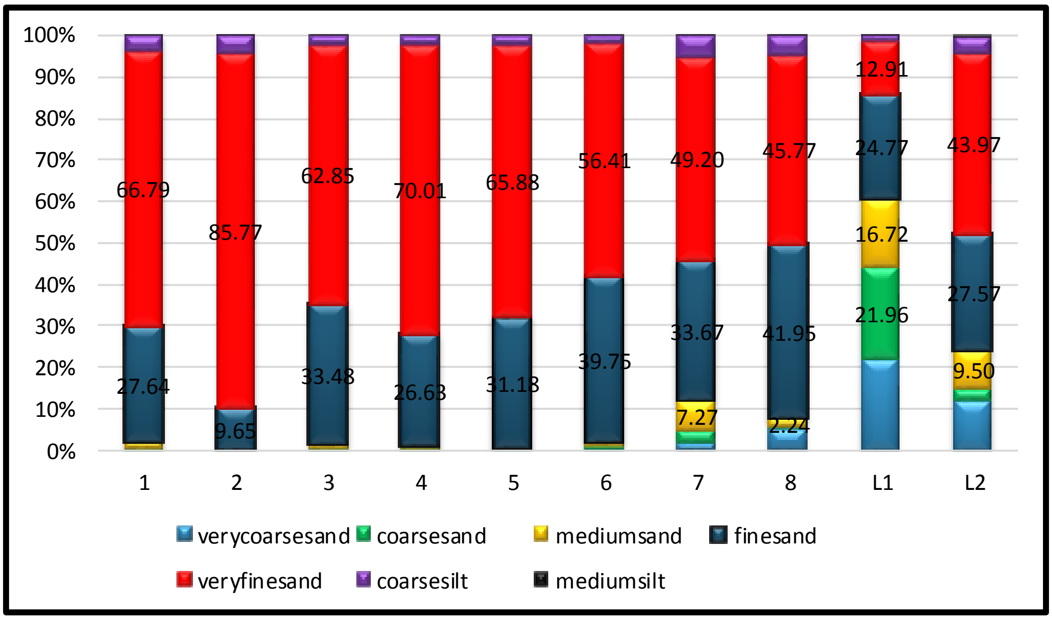


Figure 3.1-6 Comparison of the average grain size percentages for each transect

Table 3.1-3 Comparison of the average grain size percentages of each transect

Sample #	verycoarsesand	coarsesand	mediumsand	finesand	veryfinesand	coarsesilt	mediumsilt
1	0.00	0.11	1.91	27.64	66.79	3.45	0.11
2	0.00	0.04	0.29	9.65	85.77	4.18	0.07
3	0.00	0.05	1.49	33.48	62.85	2.04	0.08
4	0.00	0.06	1.15	26.63	70.01	2.01	0.14
5	0.00	0.05	0.75	31.18	65.88	2.05	0.10
6	0.18	0.73	1.17	39.75	56.41	1.70	0.06
7	1.79	2.97	7.27	33.67	49.20	5.01	0.09
8	4.90	0.55	2.24	41.95	45.77	4.45	0.14
L1	22.10	21.96	16.72	24.77	12.91	1.41	0.12
L2	12.08	2.82	9.50	27.57	43.97	3.85	0.21

The characteristics of LIM1 sub region including a wider range of size classes with closer percentages, critically differ from of the METU sub region.

○ Shape and Sort

Grain Shape (expressed as a 3-D characteristic) in this study was categorised as; very angular, sub-angular, sub-rounded, and well rounded. Also shape could be characterized by angularity being qualitative measure of the corner curvature independent of sphericity, reflecting the amount of abrasion the grain has undergone. The degree to which a sedimentary particle will be rounded depends on the energy level of the transporting process and the duration of that process. Sort – defined as the variation in size of clasts making up the sediment, was categorized as, well sorted, moderately sorted and poorly sorted. Images of microscopic examination of our samples are given in Figure 3.1-7. After microscopic examination, we determined the METU sub region samples to be composed of sub rounded and well-rounded particles. On the other side, LIM1 sub region samples were a mixture of sub-angular, sub-rounded and well-rounded particles. Both grain size analyses and microscopic examination of the samples produced the results of well sorted for the METU sub region and poorly sorted for the LIM1 sub region.

METU Sub region		
		
1.1	1.2	1.3
		
2.1	2.2	2.3
		
3.1	3.2	3.3
		
4.1	4.2	4.3
		
5.1	5.2	5.3

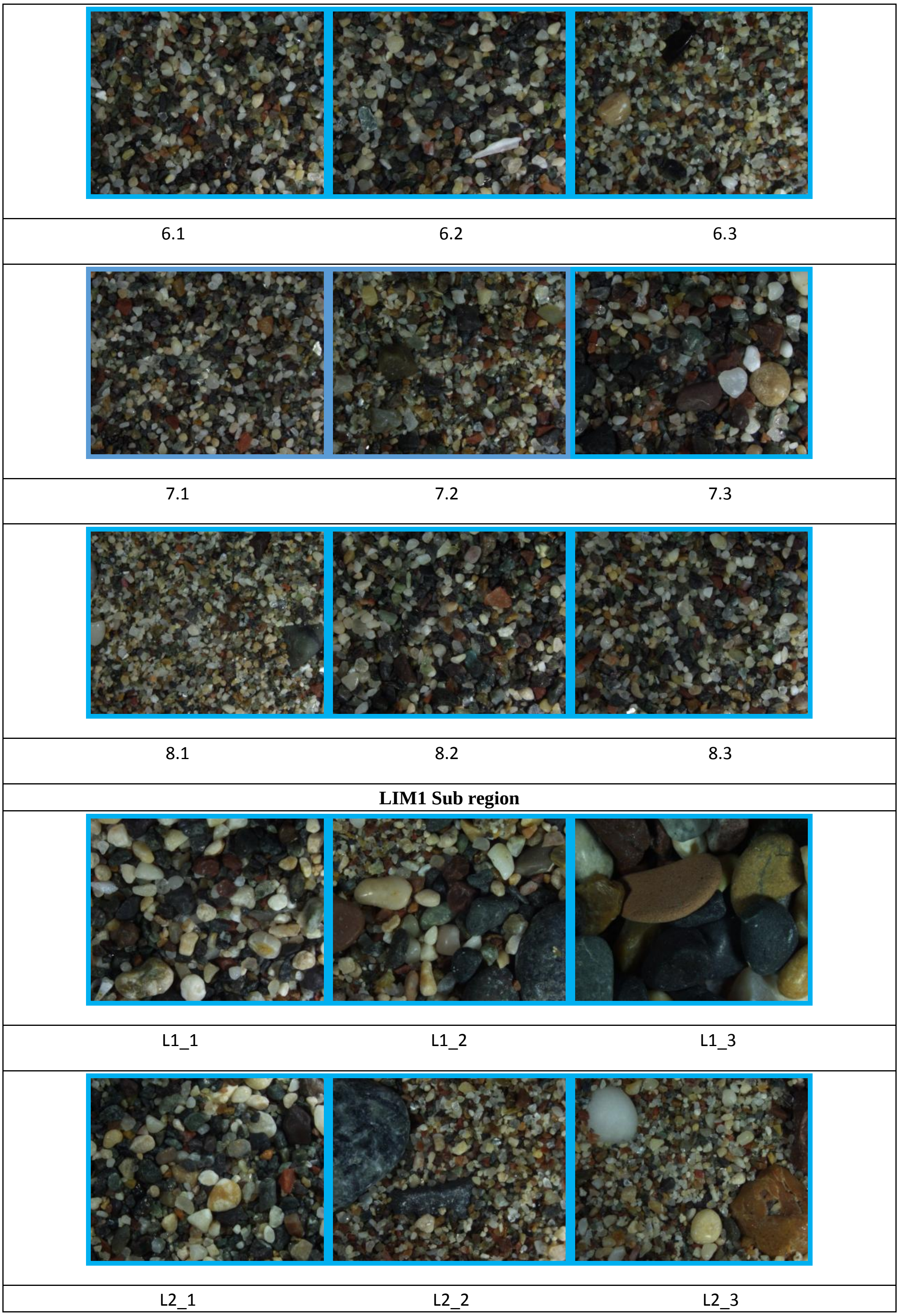


Figure 3.1-7 Microscopic examination of sand samples from METU and LIM1 sub regions

Vegetation: Documenting changes in type and condition of vegetation present, provides a useful index of habitat quality. Therefore recorded species in the 2013 nesting season along the nesting area of the beach at METU-IMS are given in Figure 3.1-8.

Figure 3.1-8 Recorded vegetation in 2013nesting season along METU-IMS

Predation Risk: crabs prey on sea turtle hatchlings and can be a hindrance during the hatchlings journey to the sea; crabs. The crabs on IMS-METU are seen in Figure 3.1-9.

Figure 3.1-9 *Ocypode cursor*

3.1.2 Insect Survey

Sand dunes are generally more variable in their richness between the zones especially in term of their invertebrate communities.

From the results observed it can be seen that there is a variation between invertebrate communities found in different sand dune zones, where each species specializes and has a different function in each zone

a)

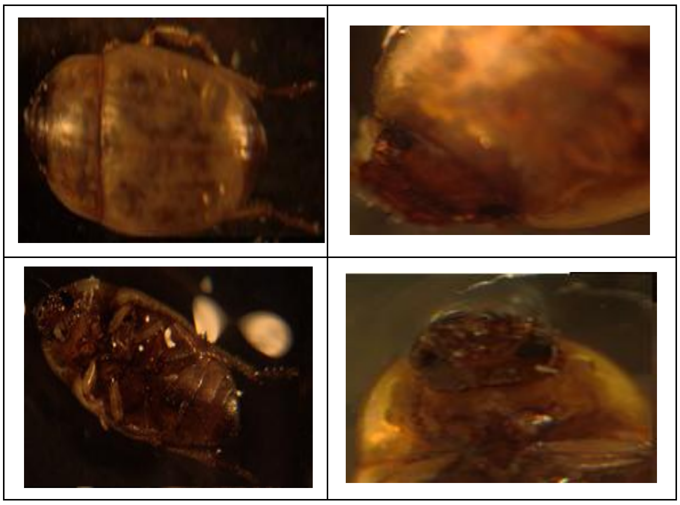


Figure 3.1-10 *Phaleria acuminate* taken by microscope

b)

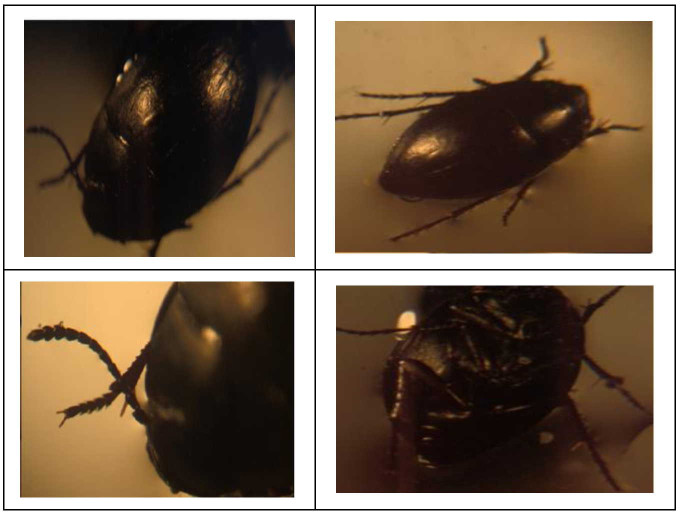


Figure 3.1-11 Tenebrionid (Darkling beetles) taken by microscope

c)

Figure 3.1-12 *Erodius siculus* taken by microscope

d)

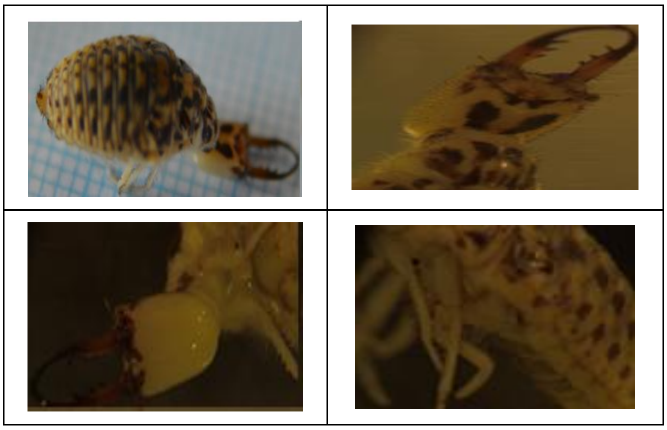


Figure 3.1-13 Myrmeleon (Ant-lion larva)

e)

Figure 3.1-14 *Buchnerillo litoralis* taken by microscope

f) Linyphiidae (Money spider)

g)

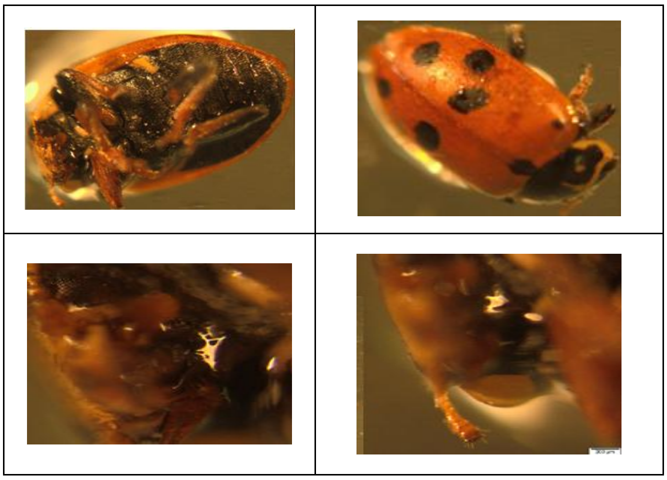


Figure 3.1-15 Coccinellidae (Ladybird) taken by microscope

h)

Figure 3.1-16 Formicidae (Ant) taken by microscope

Data obtained from the study is summarized in Table 3.1-4. The findings of this study imply that insufficient surveying was carried out during the period and could have been improved by having more replicate sets across the beach more frequently, for example instead of 6 samples, increase to 12 samples. The distance between samples could be decreased to 50m, instead of 100m, which would give a better range of species distribution. Also to improve the study number the survey should be set more than once a month. To obtain effective results, the number of surveys should be repeated around 10 times a month. Finally to observe if the invertebrate species change during the year it would be necessary to repeat the surveys during different times of year, so that changes in the invertebrate assemblage could be recorded.

Table 3.1-4 Number of invertebrates' distribution between five zones

Sample	Data type	Wet	Dry	Veg 1	Veg 2	Bushes
Sample 1	Distance to Sea	5	16	25	32	39
	Species number	1	1	0	2	0
	Individual number	a)3	b)6	0	b)5, c)5	0
Sample 2	Distance to Sea	5	14	18	23	40
	Species number	1	3	2	3	1
	Individual number	a)1	b)40, c)1, d)1	b)13, c)11	b)4, c)4, e)1	f)1
Sample 3	Distance to Sea	5	13	21	27	35
	Species number	1	2	3	1	0
	Individual number	a)2	b)14, c)2	b)3, c)1, d)1	b)1	0
Sample 4	Distance to Sea	5	19	26	31	36
	Species number	1	1	0	1	0
	Individual number	g)1	b)11	0	h)1	0
Sample5	Distance to Sea	5	17	24	28	32
	Species number	0	1	1	0	0
	Individual number	0	b)17	e)2	0	0
Sample6	Distance to Sea	4	14	21	24	31
	Species number	1	2	2	0	1
	Individual number	a)2	b)15, i)1	b)3, i)1	0	e)16

*Wet sand (WS), Dry sand (DS), Vegetation 1 *Pancratium maritimum*, Vegetation 2 *Salosola kali* and Bush vegetation above 0.5m found in all six samples

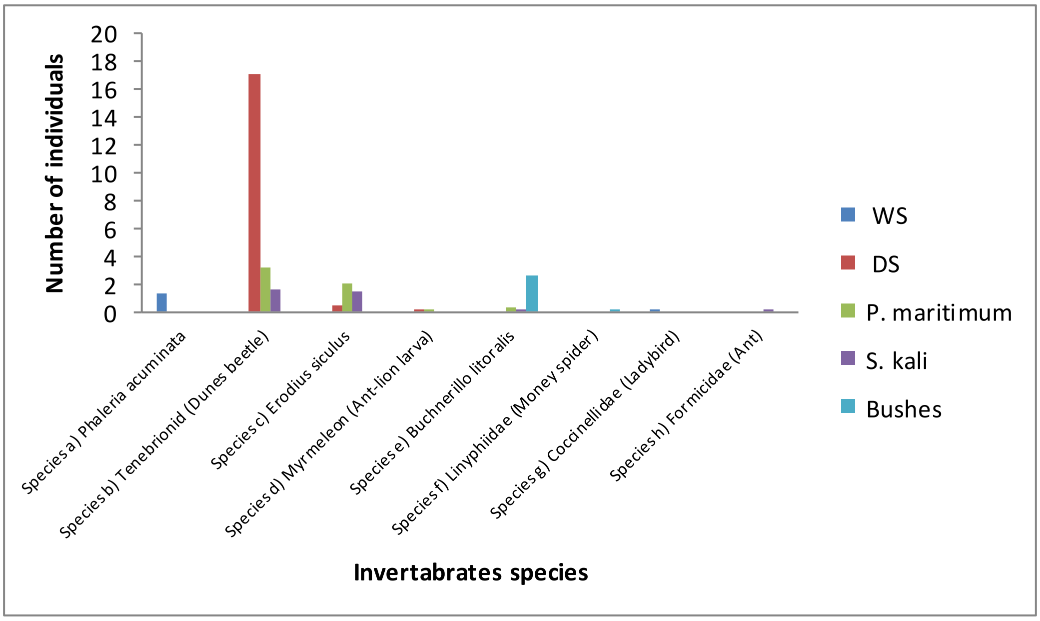


Figure 3.1-17Number of invertebrates' distribution between five zones*

* Wet sand (WS), Dry sand (DS), Vegetation 1 *Pancratium maritimum*, Vegetation 2 *Salosola kali* and Bush vegetation above 0.5m

3.2 Nesting Activities of Sea Turtles

To monitor sea turtles' nesting emergences two different techniques were used. In this Section firstly results obtained by daily regular night and morning patrols will be given supported later by the data obtained by the infrared camera-laser beam system

3.2.1 Nesting Activities Monitored by Daily Patrols

In the 2013 nesting season, after construction of the camera-laser beam system had finished at the beginning of May, the system was activated and daily morning track monitoring began on 01.06.2013. The earliest turtle (*Caretta caretta*) emergence occurred on 22.05.2013. After that date night patrol monitoring was also included in the routine monitoring program until mid-October. During data collection emergences were grouped into three categories on the basis of the turtle's behavior and pattern of movement. However data analysis was carried out on the basis of whether emergence resulted in nest construction or not using the classification system of fake and nesting crawls. Here fake crawls were also classified as no nest data. Another reason for using this classification during analysis is to standardize results to make the study comparable with others. In the results both data sets are given but analysis was made by only the standard terminology.

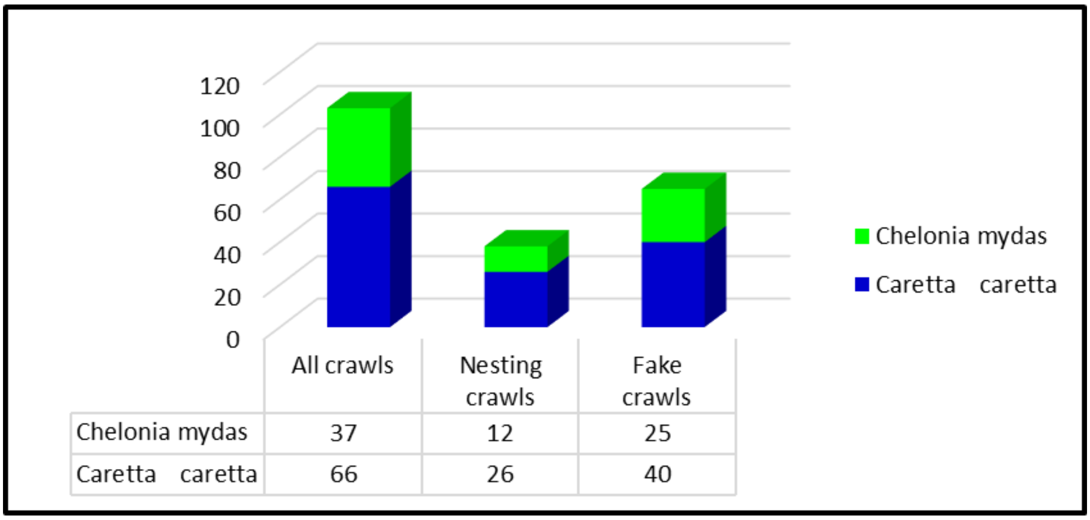
3.2.1.1 Emergences and Nest Densities

In total, 103 emergences occurred during the 2013 nesting season along METU-IMS. Of these, 66 were *Caretta caretta* species, of which 26 resulted in nesting. For *Chelonia mydas* species, of 37 emergences, 12 resulted in nesting summarized in Table

3.2-1. Figures 3.2-1, 3.2-2 illustrate fake nests and no nest attempts separately.

Table 3.2-1 Emergences and nest density percentages for each species at METU-IMS in the 2013 nesting season

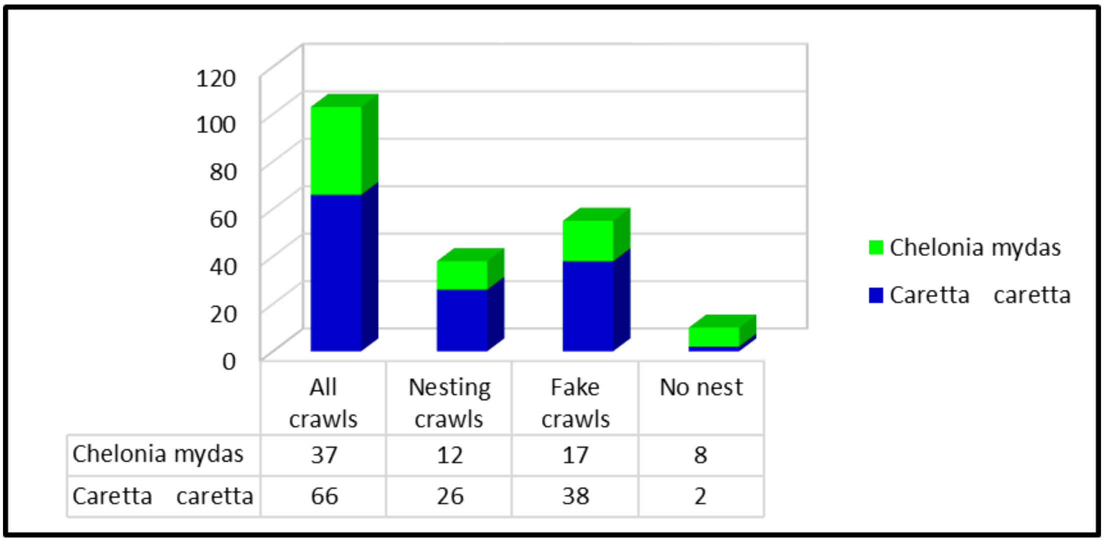
Species	**All crawls**	**%**	**Nesting crawls**	**%**	**Fake crawls**	**%**	**Distance (km)**	**Nest density (N/km)**
Caretta caretta	66	64.08	26	68.42	40	61.54	2.60	10.00
Chelonia mydas	37	35.92	12	31.58	25	38.46	2.60	4.62
Both species	103	100.00	38	100.00	65	100.00	2.60	14.62



	All crawls	Nesting crawls	Fake crawls
Chelonia mydas	37	12	25
Caretta caretta	66	26	40

Figure 3.2-1 Comparison of fake and nesting crawls between species in the 2013 nesting season at METU-IMS

When emergence numbers were taken into consideration, the exact location of the emerged female was accepted for also translocated nests. Only for translocated nests, both emergence and translocated locations were recorded. Due to data relating to incubation period, the translocated position was used, whereas the spatial preferences of the female were shown with their first emergence geographic point shown in the Arc- GIS Maps represented as; Figure 3.2-3 and Figure 3.2-4 which show a general picture of the emergences belonging to each species indicating the nesting situation with different colors.



	All crawls	Nesting crawls	Fake crawls	No nest
Chelonia mydas	37	12	17	8
Caretta caretta	66	26	38	2

Figure 3.2-2 Comparison of nesting crawls and others divided into fake crawls and no nest between species in the 2013 nesting season at METU-IMS

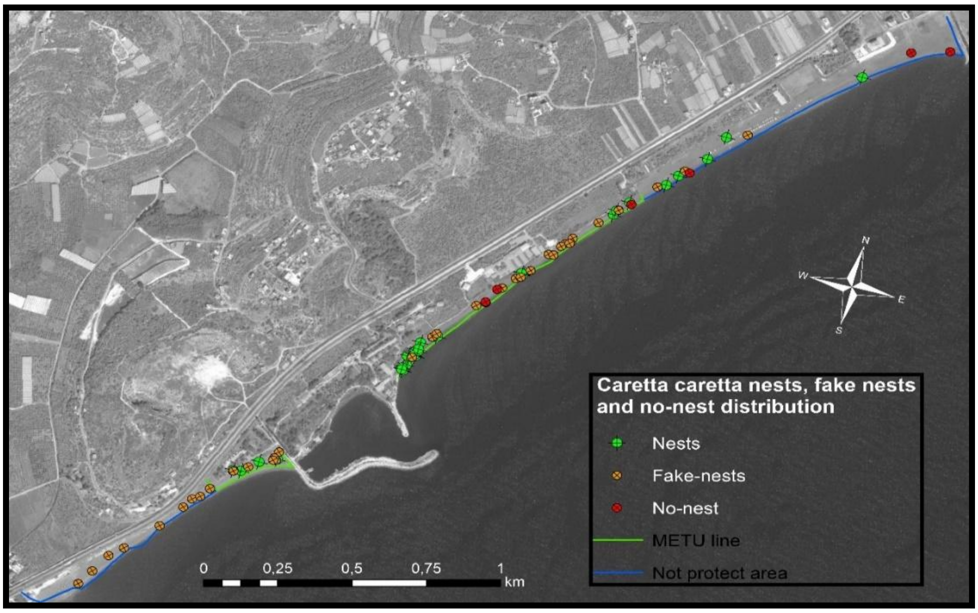


Figure 3.2-3 Distribution of Loggerhead turtle emergences along the METU-IMS Beach in 2013

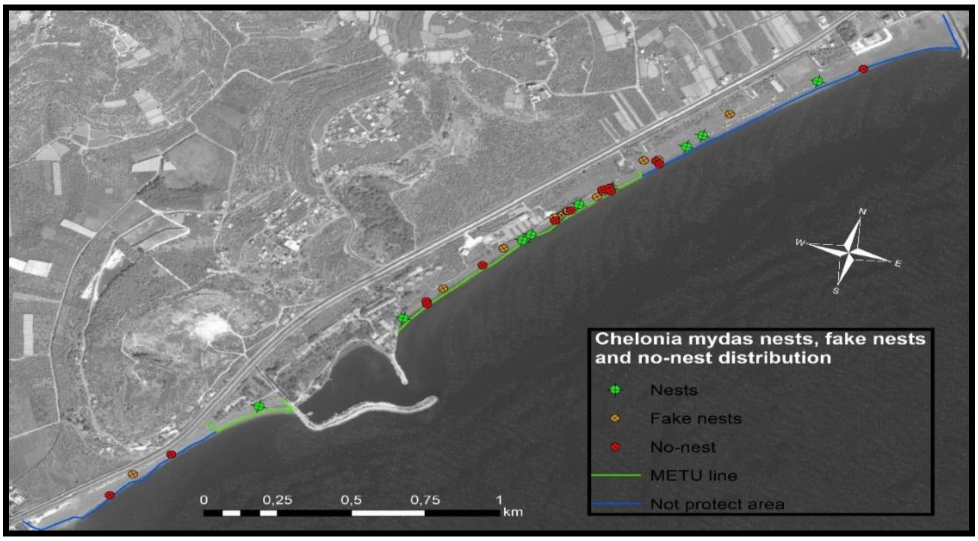


Figure 3.2-4 Distribution of Green turtle emergences along the METU-IMS Beach in 2013

The study site is an important nesting place for both species. 25 *Caretta caretta* nests and 12 *Chelonia mydas* nests totaling 37 nests are shown in Figure 3.2-5 with 4 of the translocated loggerhead nests (2 from KOCA, 1 from outside the region further east of the zone KOCA and the final one from LIM to the METU zone).

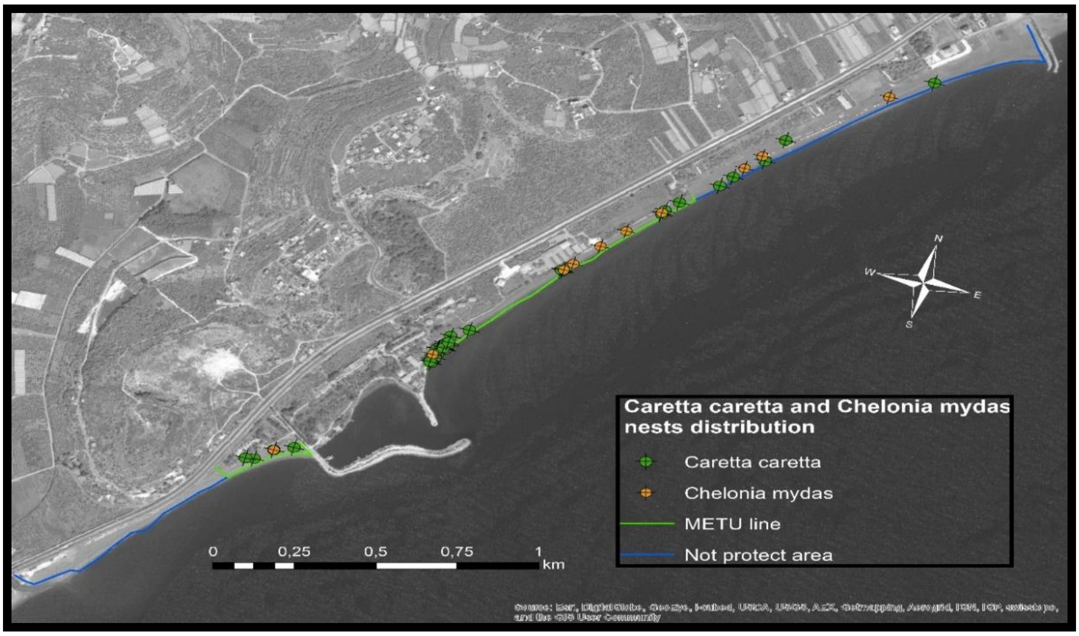


Figure 3.2-5 Distribution of nests along the METU-IMS Beach in 2013

3.2.1.2 Spatial Distribution of emergences and nests

To consider the spatial distribution for subsections, the number and ratio of the crawls for each nesting situation, is summarized in Table 3.2-2.

Table 3.2-2 Distribution of all emergences as nesting crawls, fake crawls and no nest, and nest densities for each zone

Species	Zone	All crawls	%	Nesting crawls	%	Fake crawls	%	No nest	%
Caretta caretta	METU	35	53.03	15	22.73	20	30.30	0	0.00
	KOCA	13	19.70	8	12.12	3	4.55	2	3.03
	LIM1	13	19.70	2	3.03	11	16.67	0	0.00
	LIM2	5	7.58	1	1.52	4	6.06	0	0.00
	Total	**66**	**100.00**	**26**	**39.39**	**38**	**57.58**	**2**	**3.03**
Chelonia mydas	METU	26	70.27	8	21.62	13	35.14	5	13.51
	KOCA	7	18.92	3	8.11	1	2.70	3	8.11
	LIM1	4	10.81	1	2.70	3	8.11	0	0.00
	LIM2	0	0.00	0	0.00	0	0.00	0	0.00
	Total	**37**	**100.00**	**12**	**32.43**	**17**	**45.95**	**8**	21.62
Both species	METU	61	59.22	23	22.33	33	32.04	5	4.85
	KOCA	20	19.42	11	10.68	4	3.88	5	4.85
	LIM1	17	16.50	3	2.91	14	13.59	0	0.00
	LIM2	5	4.85	1	0.97	4	3.88	0	0.00
	Total	**103**	**100.00**	**38**	**36.89**	**55**	**53.40**	**10**	**9.71**

In order to relate these crawl ratios, nest densities are given in Table 3.2-3 for accurate comparison of the subsections to their different distances. Nest density parameters could be comparable for other study sites explained in the discussion. Throughout the monitoring, in order to observe the nesting behavior of the female emergences which did not result in nesting, two groups labelled fake nest and no nest are summarized in Figure 3.2-6. But analysis based on whether emergence resulted with nesting or not is applied by using standard terminology as fake nests and nesting crawls as summarized in the Figure Figure 3.2-7.

Table 3.2-3 Distribution of all emergences as nesting crawls and fake crawls and nest densities for each zone

Species	Zone	All crawls	Nesting crawls	Fake crawls	Distance (km)	Nest density (N/km)	fake crawl/ nesting crawl
Caretta caretta	METU	35	15	20	0.80	18.75	1.33
	KOCA	13	8	5	1.00	8.00	0.63
	LIM1	13	2	11	0.20	10.00	5.50
	LIM2	5	1	4	0.60	1.67	4.00
	Total	**66**	**26**	**40**	**2.60**	10.00	1.54
Chelonia mydas	METU	26	8	18	0.80	10.00	2.25
	KOCA	7	3	4	1.00	3.00	1.33
	LIM1	4	1	3	0.20	5.00	3.00
	LIM2	0	0	0	0.60	0.00	0.00
	Total	**37**	**12**	**25**	**2.60**	4.62	2.08
Both species	METU	61	23	38	0.80	28.75	1.65
	KOCA	20	11	9	1.00	11.00	0.82
	LIM1	17	3	14	0.20	15.00	4.67
	LIM2	5	1	4	0.60	1.67	4.00
	Total	**103**	**38**	**65**	**2.60**	14.62	1.71

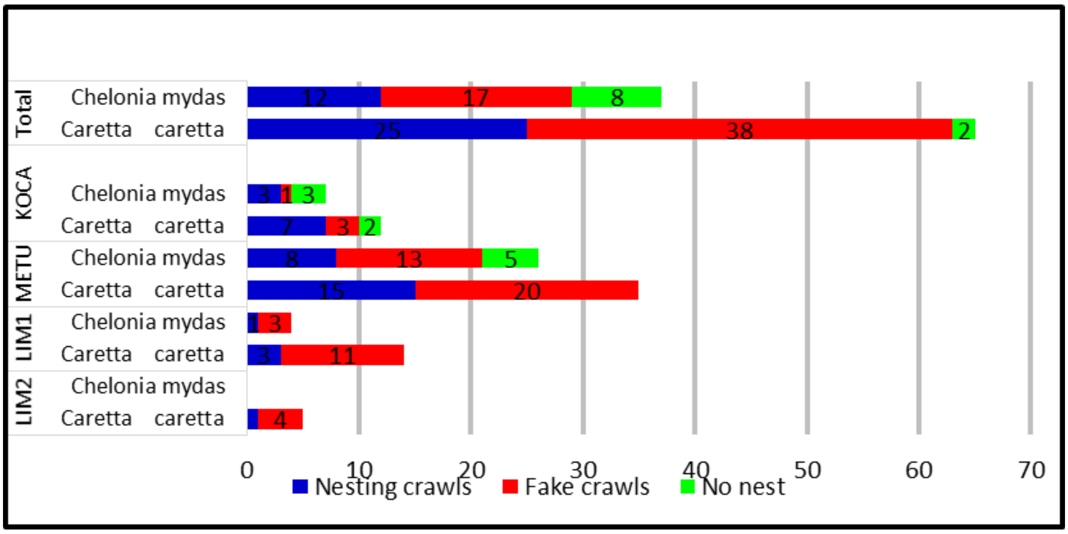


Figure 3.2-6 Distribution of all emergences as nesting crawls, fake crawls and no nest, and nest densities for each zone

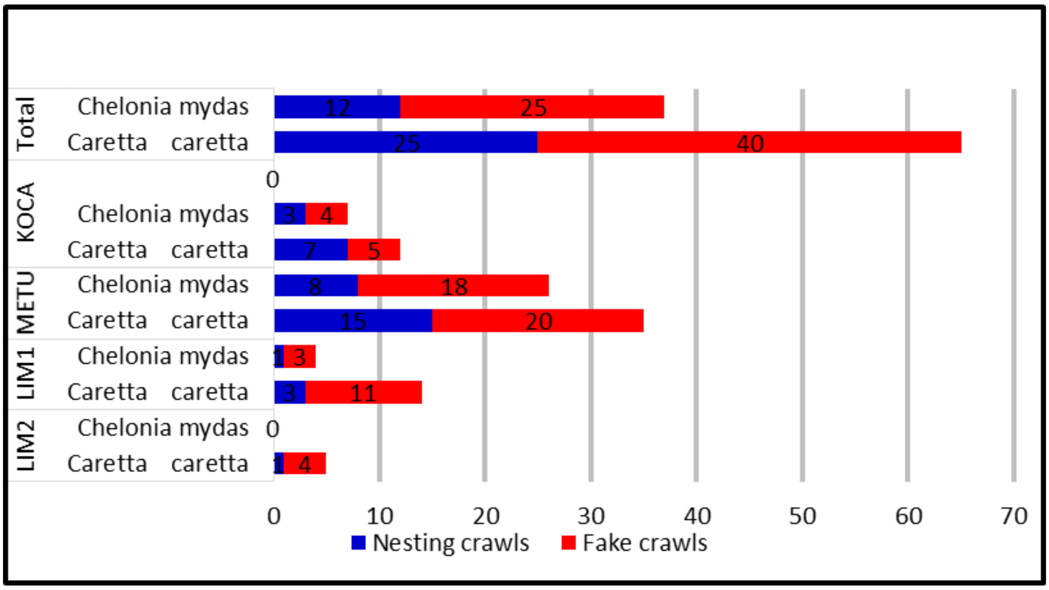


Figure 3.2-7 Distribution of all emergences as nesting crawls and fake crawls and nest densities for each zone

All zones are first considered separately before comparison with each other. It is clearly understood from Figure 3.2-6 and Figure 3.2.7 for both species that fake crawls and nesting crawls were concentrated in the METU zone. All the sub -regions will be detailed in following sections.

<u>Zone 1 and Zone 2- LIM2 and LIM1:</u>

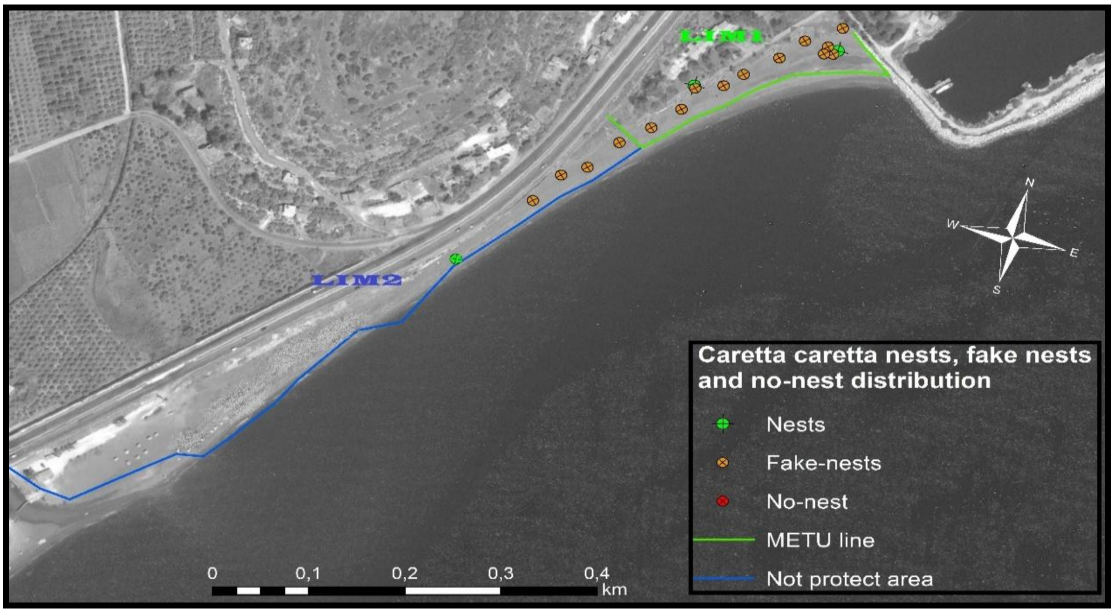


Figure 3.2-8 Distribution of Loggerhead turtle emergences along subsections LIM2 and LIM1 in the 2013 nesting season

In zone LIM2 for loggerhead turtles, four emergences were fake crawls while only one emergence resulted in a nesting crawl as seen in Figure 3.2-8. Moreover, due to the close proximity of the nest to the sea (1 meter) it was translocated to LIM1 with the aim of protecting the nest from being washed away and from the effects of intense human disturbance in LIM2. In the LIM1 region as part of our campus site there were a total of 13 emergences, among which 11 fake crawls and 2 nesting crawls are summarized in Table 3.2-4.

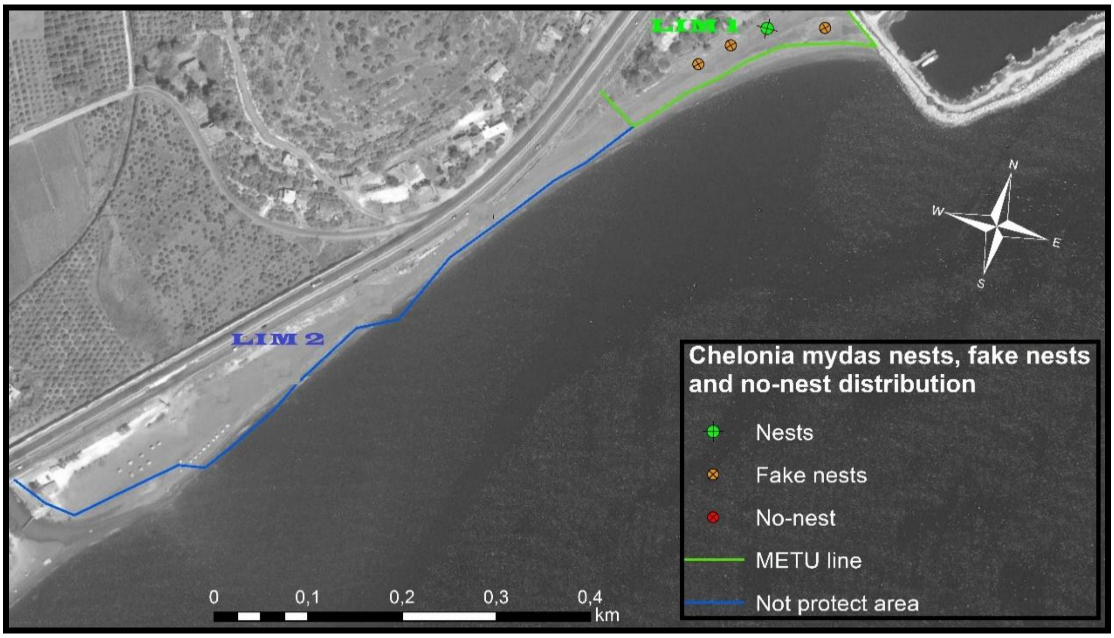


Figure 3.2-9 Distribution of Green turtle emergences along subsections LIM2 and LIM1 in the 2013 nesting season

Table 3.2-4 Number of Loggerhead and Green turtle emergences along LIM2 and LIM1 in 2013 the nesting season

Zone	Coordinates				Distance (km)
	Start point		End point		
LIM2	36°33'44.35'	34°15'6.04"E	36°33'28.59"	34°14'51.05"E	0.60
species	**All crawls**	**Nesting crawls**	**Fake crawls**	**Nesting Success**	**Nest density (N/km)**
Caretta caretta	5.00	1	4	20.00	1.67
Chelonia mydas	0.00	0	0	0.00	0.00
Zone	**Coordinates**				**Distance (km)**
	Start point		**End point**		
LIM1	36°33'48.85'	34°15'12.34"E	36°33'44.35"	34°15'6.04"E	0.20
species	**All crawls**	**Nesting crawls**	**Fake crawls**	**Nesting Success**	**Nest density (N/km)**
Caretta caretta	13.00	2	11	15.38	0.85
Chelonia mydas	4.00	1	3	25.00	0.16

There were no green turtle emergences at LIM2, whilst at LIM1 there were 5 emergences in total but only one of them resulted with nesting and the remaining 4 were fake crawls summarized in Table 3.2-2 and shown in Figure 3.2-9 .

Zone 3 – METU:

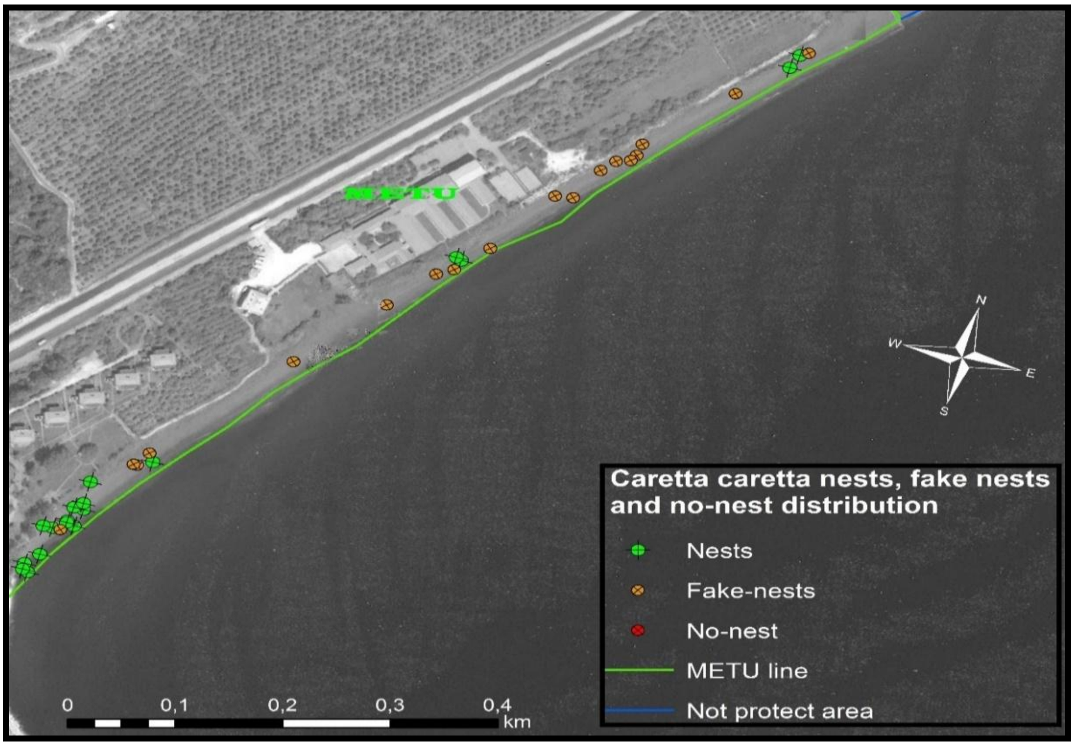


Figure 3.2-10 Distribution of loggerhead turtle emergences along subsection METU in the 2013 nesting season

Loggerhead turtles which emerged at the most condensed zone –METU, mostly nested at the beginning of the zone and fake crawls were mainly distributed along other parts of this zone as seen in Figure 3.2-10. There were 15 nesting crawls and 20 fake crawls for loggerheads in the 2013 nesting season, 3 of the nests from KOCA zone were translocated to METU zone just after the females had lain the eggs. The main reasons behind the translocation were, high artificial light intensity, nest location too close to the sea and therefore danger of submergence and high human disturbance from the beach camping site. One nest was translocated to METU zone after researchers were alerted by a conscientious member of the public that a loggerhead nest was positioned right on the high tide line. This condensed sub region displayed highest vegetation levels among all sub-regions and is covered by sand dunes, showed a spatially reciprocal nesting trend with loggerheads as nesting crawls were mainly found at the end of the zone in the 2013 nesting season.

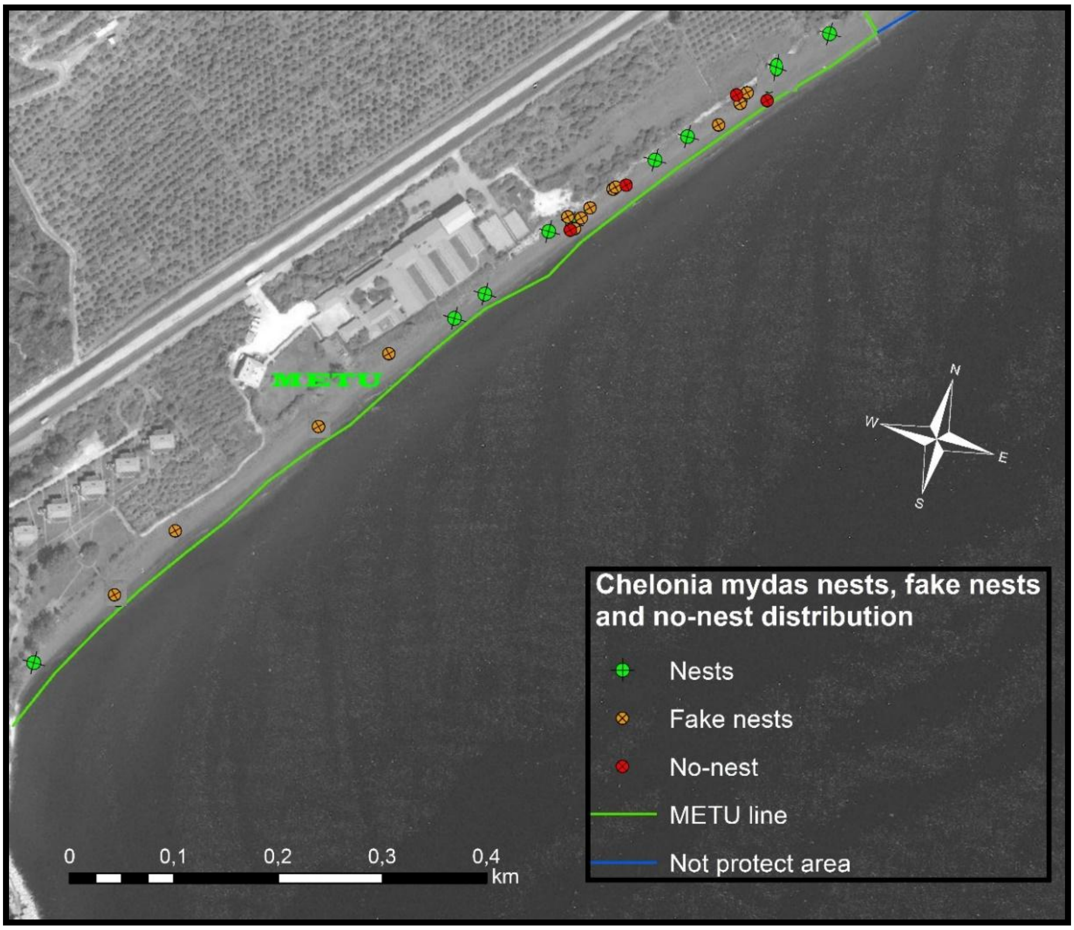


Figure 3.2-11 Distribution of green turtle emergences along subsection METU in the 2013 nesting season

Only one of the 8 nests found in the first part of the zone where loggerheads focused belonged to a green turtle. 13 fake crawls and 5 no nest attempt were recorded for this zone. The distribution of green turtle emergences is represented in Figure 3.2-11 the number of nesting and false crawls are summarized in Table 3.2-5 for both species indicating that of 26 emergences, 8 resulted in nests.

Table 3.2-5 Number of loggerhead and green turtle emergences along METU in the 2013 nesting season

Zone	Coordinates				Distance (km)
	Start point		End point		
METU	36°33'58.2	34°15'21.68"E	36°34'20.95"	34°15'41.74"E	0.80
species	**All crawls**	**Nesting crawls**	**Fake crawls**	**Nesting Succes**	**Nest density (N/km)**
Caretta caretta	35.00	15	20	42.86	18.75
Chelonia mydas	26.00	8	18	30.77	10.00

Zone 4: KOCA

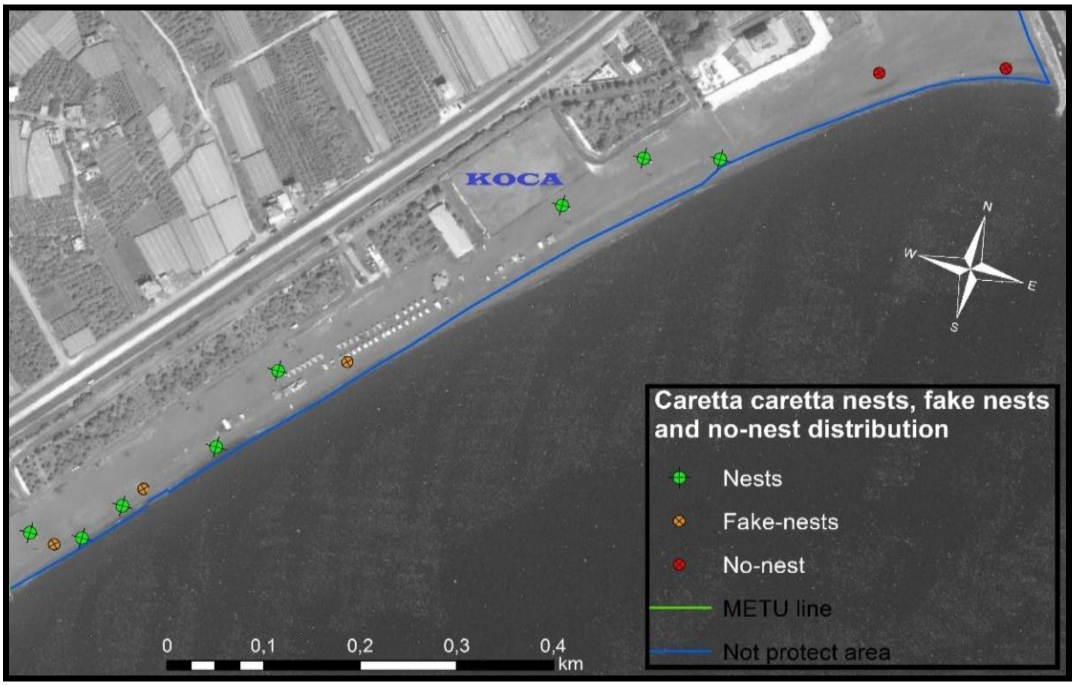


Figure 3.2-12 Distribution of loggerhead turtle emergences along subsection KOCA in the 2013 nesting season

For the KOCA zone, the number of emergences for both species is given in Table 3.2-6 and shown in Figure 3.2-12 for loggerheads and in Figure 3.2-13 for green turtles. Loggerheads again displayed a higher nest density and nesting success than green turtles. Based on both nesting success and nest density rates, the green turtle values were lower than those of loggerheads as for LIM2, LIM1, and METU zone with an exception of lower loggerhead nesting success in LIM1 due to the high false crawl number as compared with green turtle emergences in this zone.

Table 3.2-6 Number of loggerhead and green turtle emergences along subsection KOCA in the 2013 nesting season

Zone	Coordinates				Distance (km)
	Start point		End point		
KOCA	36°34'20.95"I	34°15'41.74"E	36°34'43.63'	34°16'9.48"E	1.00
species	**All crawls**	**Nesting crawls**	**Fake crawls**	**Nesting Success**	**Nest density (N/km)**
Caretta caretta	13.00	8	5	61.54	8.00
Chelonia mydas	7.00	3	4	42.86	3.00

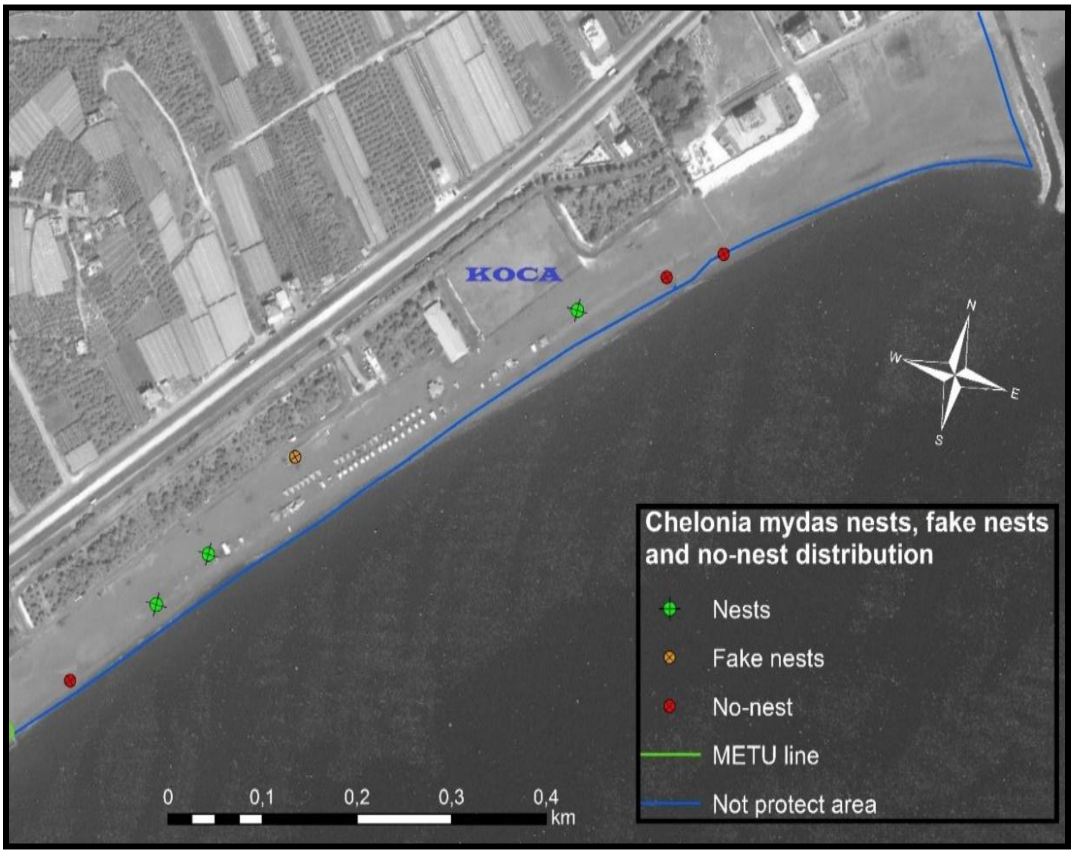


Figure 3.2-13 Distribution of green turtle emergences along subsection KOCA in the 2013 nesting season

3.2.1.3 Temporal Distribution of emergences

Following the spatial distribution of nesting attempts along METU-IMS, the seasonal/ monthly distributions of the emergences for each species categorized as nesting crawls, fake crawls and no nests for each sub-region along the study site in the 2013 nesting season are given here. Temporal distribution is also compared for species. Emergences of loggerheads at METU-IMS for the entire study site mainly occurred in July and for in June for green turtles shown in

Table 3.2-7. Although the number of loggerhead emergences were highest in July, the highest numbers of nesting crawls were observed in June. In terms of nesting crawls, June was the most active month for both species shown in Figure 3.2-14 and Figure 3.2-15.

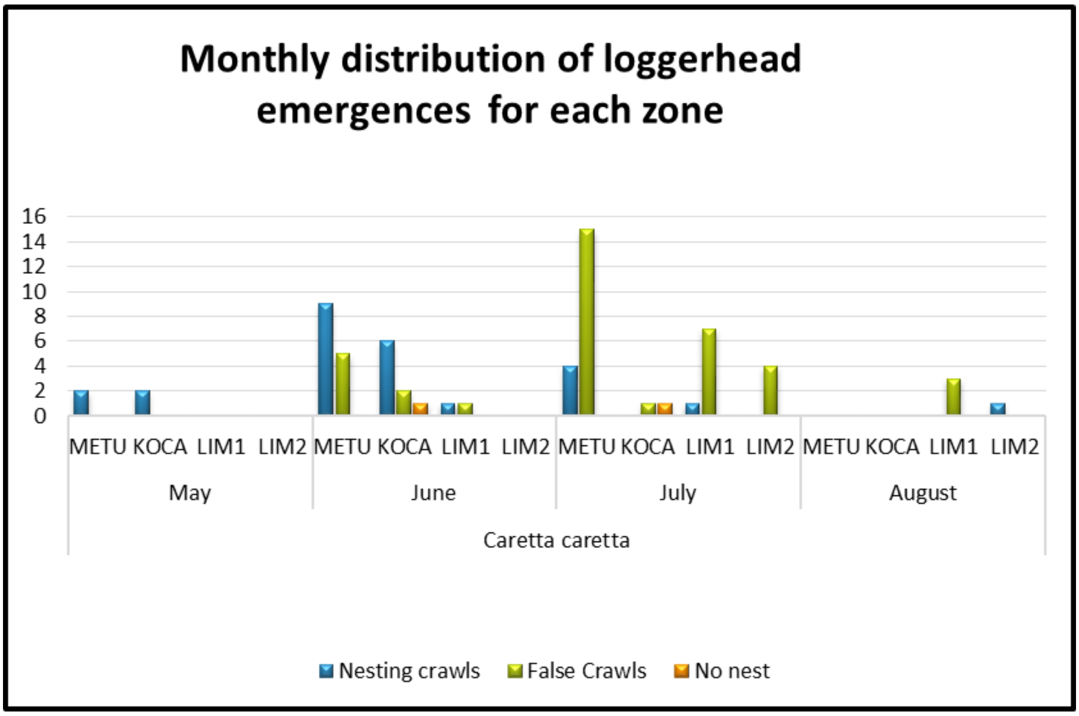


Figure 3.2-14 Temporal distribution of loggerhead emergences on METU-IMS in the 2013 breeding season

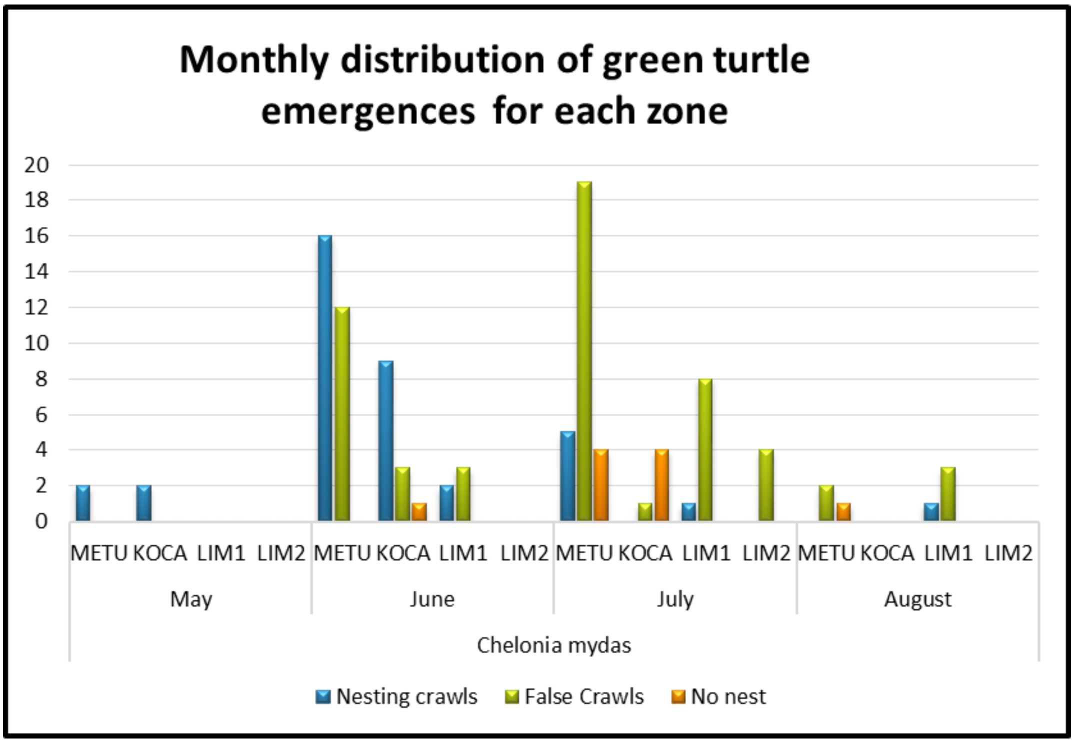


Figure 3.2-15 Temporal distribution of green turtle emergences on METU-IMS in the 2013 breeding season

Table 3.2-7 Temporal distribution of the emergences for each species for the zones in 2013 nesting season on METU-IMS Beach

Species	Months	Zone	Nesting crawls	False crawls	No nest	All crawls
Caretta caretta	May	METU	2.00	0.00	0.00	2.00
		KOCA	2.00	0.00	0.00	2.00
		Total	4.00	0.00	0.00	4.00
	June	METU	9.00	5.00	0.00	14.00
		KOCA	6.00	2.00	1.00	9.00
		LIM1	1.00	1.00	0.00	2.00
		Total	16.00	8.00	1.00	25.00
	July	METU	4.00	15.00	0.00	19.00
		KOCA	0.00	1.00	1.00	2.00
		LIM1	1.00	7.00	0.00	8.00
		LIM2	0.00	4.00	0.00	4.00
		Total	5.00	27.00	1.00	33.00
	August	LIM1	0.00	3.00	0.00	3.00
		LIM2	1.00	0.00	0.00	1.00
		Total	1.00	3.00	0.00	4.00
Chelonia mydas	June	METU	7.00	7.00	0.00	14.00
		KOCA	3.00	1.00	0.00	4.00
		LIM1	1.00	2.00	0.00	3.00
		LIM2	0.00	0.00	0.00	0.00
		Total	11.00	10.00	0.00	21.00
	July	METU	1.00	4.00	4.00	9.00
		KOCA	0.00	0.00	3.00	3.00
		LIM1	0.00	1.00	0.00	1.00
		Total	1.00	5.00	7.00	13.00
	August	METU	0.00	2.00	1.00	3.00
		Total	0.00	2.00	1.00	3.00
Both species	May	METU	2.00	0.00	0.00	2.00
		KOCA	2.00	0.00	0.00	2.00
		Total	4.00	0.00	0.00	4.00
	June	METU	16.00	12.00	0.00	28.00
		KOCA	9.00	3.00	1.00	13.00
		LIM1	2.00	3.00	0.00	5.00
		Total	27.00	18.00	1.00	46.00
	July	METU	5.00	19.00	4.00	28.00
		KOCA	0.00	1.00	4.00	5.00
		LIM1	1.00	8.00	0.00	9.00
		LIM2	0.00	4.00	0.00	4.00
		Total	6.00	32.00	8.00	46.00
	August	METU	0.00	2.00	1.00	3.00
		LIM1	1.00	3.00	0.00	4.00
		LIM2	0.00	0.00	0.00	0.00
		Total	1.00	5.00	1.00	7.00

The comparison of temporal distribution among species is given in Figure 3.2-16

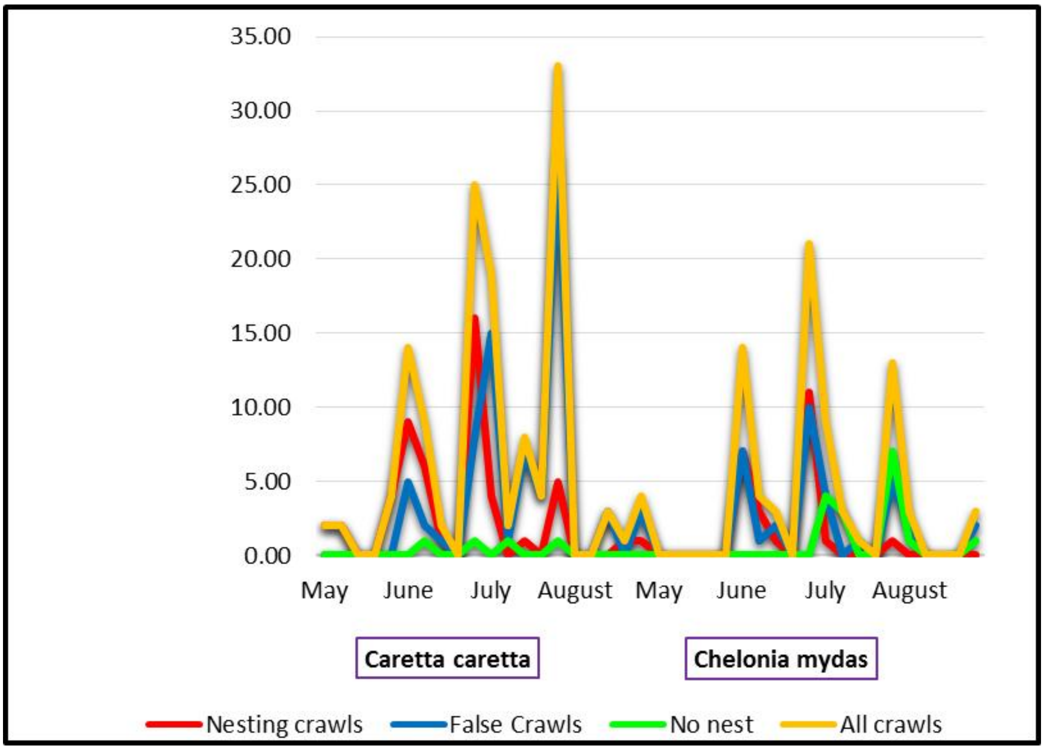


Figure 3.2-16 Temporal distribution of emergences for each species during the 2013 nesting season along METU-IMS Beach.

Whereas the emergences began in May for loggerheads, they began in June for green turtles. For both species, nesting attempts finished in August for the 2013 nesting season as shown in Figure 3.2-16. The data shows that the maximum number of emergences were equally shared in June and July however this differs when the data is categorised as nesting crawls and fake crawls. Although the total number of emergences is the same for these two months, the ratio of nesting crawls and fake crawls differs. It is observed that June has a nearly five fold nesting crawl value. Total emergences of loggerheads was listed in decreasing order as July, June, and May- August. Nesting emergences also listed in this manner are; June, July, May and August. For the green turtles, all emergences were listed in decreasing order as June, July and August. Nesting emergences reached the maximum in June, followed by July. The first emergences began in May for loggerheads and in June for green turtles. A total of 103 emergences were recorded with 66 being loggerhead emergences with 26 nesting crawls and 37 green turtle emergences with12 nesting crawls. Among these loggerhead nesting crawls; 4 (15.38 %) were recorded in May, 16 (61.54%) in June, 5 (19.23%) in July and 1 (3.85 %) in August. For green turtle nesting crawls; 11 (91.67 %) were recorded in June and 1 (8.33 %) in July. Green turtles opened the nesting season later than the loggerheads. Green turtles made the the most attempts and nests in June. Their no nesting emergences reached a peak value in July and was higher than for loggerheads. The higher no nest values also were recorded for June, July and August.

3.2.1.4 Nesting Success

Nesting Success (NS) is calculated from the number of successful nesting attempts using the formula:

$$NS\ (\%) = 100 * [(N)/(N+T)]$$

Where N is the number of the nests and T is the number of tracks without successful nesting.

Table 3.2-8 Nesting success percentages for each species at METU-IMS in the 2013 nesting season

Species	All crawl	Nesting crawl	Fake crawl	Distance (km)	Nest density (N/km)	Nesting Success (%)
Caretta caretta	66	26	40	2.60	10.00	39.39
Chelonia mydas	37	12	25	2.60	4.62	32.43
Both species	103	38	65	2.60	14.62	36.89

From Table 3.2-8 it is easily seen that the number of loggerhead turtles nesting attempts is higher than green turtles with a ratio of 1.78. Comparisons were made using nest density data (10.00 for *Caretta caretta*, 4.62 for *Chelonia mydas*) and percentage nesting success (39.39 for *Caretta caretta*, 32.43 for *Chelonia mydas*). When nesting success is examined between the subsections in Table 3.2-9 the KOCA sub region has the highest nesting success for both species, followed by the METU sub region which has highest nest density values for each species. The worst sub region in terms of nesting success and nest density is LIM2. LIM1 has lower values than KOCA and METU, but higher values than LIM2. Not every nest results in hatching successfully, survivor nest percentage is calculated by the following formula:

Survivor Nest (%) = 100*(S/N)

Where S is the number of nests that successfully completed incubation (at least one successful hatchling is needed for validation of survival), and N is the total number of nests resulting in a 97.37% success rate for METU- IMS in 2013.

Table 3.2-9 Nesting success distributed spatially for both species

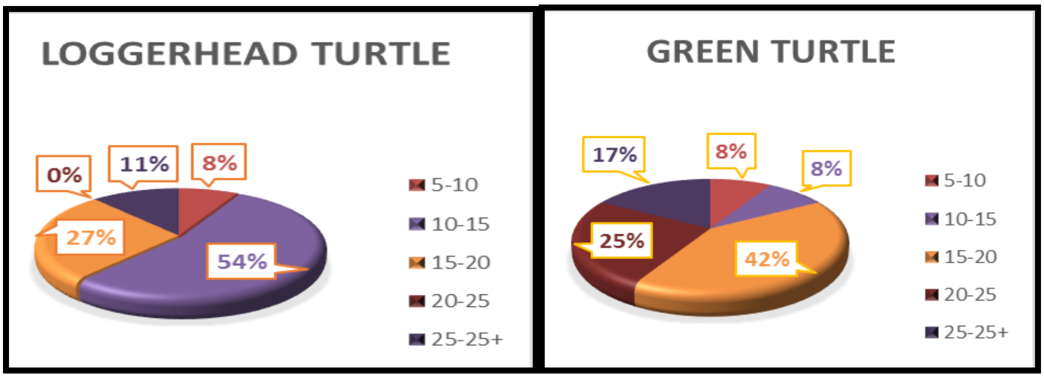
Species	Zone	All crawls	Nesting crawls	Fake crawls	Distance (km)	Nest density (N/km)	fake crawl/ nesting crawl	Nesting Success
Caretta caretta	METU	35	15	20	0.80	18.75	1.33	42.86
	KOCA	13	8	5	1.00	8.00	0.63	61.54
	LIM1	13	2	11	0.20	10.00	5.50	15.38
	LIM2	5	1	4	0.60	1.67	4.00	20.00
	Total	**66**	**26**	**40**	**2.60**	10.00	1.54	39.39
Chelonia mydas	METU	26	8	18	0.80	10.00	2.25	30.77
	KOCA	7	3	4	1.00	3.00	1.33	42.86
	LIM1	4	1	3	0.20	5.00	3.00	25.00
	LIM2	0	0	0	0.60	0.00	0.00	0.00
	Total	**37**	**12**	**25**	**2.60**	4.62	2.08	32.43
Both species	METU	61	23	38	0.80	28.75	1.65	37.70
	KOCA	20	11	9	1.00	11.00	0.82	55.00
	LIM1	17	3	14	0.20	15.00	4.67	17.65
	LIM2	5	1	4	0.60	1.67	4.00	20.00
	Total	**103**	**38**	**65**	**2.60**	14.62	1.71	36.89

3.2.1.5 The width of wet, semi-wet, dry regions

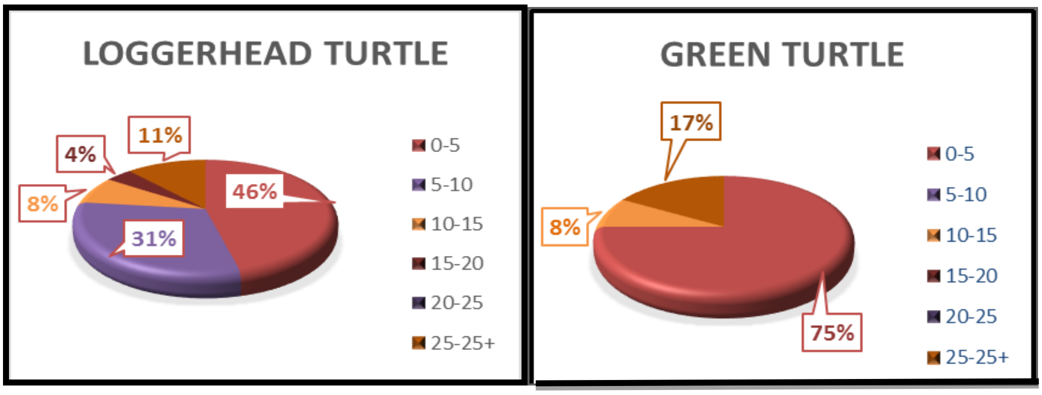
For each nest distance measurements were taken from dry sand, semi-wet sand, wet sand and vegetation. Averages of data separated for both species and sub regions are summarized in Table 3.2-10. The average distance to sea water for loggerhead nests was 14.71±5.52 m and for green turtle nests was 20.79±11.55 m.Moreover, the average distance to the vegetation was 14.00±14.89 for loggerheads and 6.23±12.93 m for green turtles. Loggerheads' major preference was 10-15 meter group to the sea, while green turtle nests focused on 15-20 meter group to the sea. The case for vegetation showed that 75% of the green turtle nests were placed at maximum 5 meters to the vegetation compared to 46% of the loggerhead nests placed in this zone. When the beach was subdivided into 5 meter sections from nest to the sea water the distribution of nests is seen in Figure 3.2-17.

Table 3.2-10 Average Distance measurements of nests specific to both species and Zones in 2013 on METU-IMS Beach

Species	Zones	Distance measurements					
		N	Avr.Dry±S.Dev	AvrS.wet	Wet±S.Dev	Avr.Sea±S.Dev	Avr.Veg±S.Dev
Caretta caretta	LIM1	2	3.60 ± 5.09	11.05 ± 7.28	6.7 ± 0.57	21.35 ± 2.76	14.65 ± 2.19
	METU	15	6.22 ± 2.73	3.31 ± 1.43	4.55 ± 1.93	14.17 ± 3.08	6.00 ± 2.65
	KOCA	8	6.59 ± 7.46	3.85 ± 2.68	3.63 ± 1.59	14.06 ± 8.42	29.34± 18.18
	Total	25	6.13 ± 4.72	4.16 ± 3.14	4.42 ± 1.89	14.71 ± 5.52	14.00 ± 14.89
Chelonia mydas	LIM1	0	0.00	0.00	0.00	0.00	0.00
	METU	8	10.21 ± 3.90	2.5 ± 1.85	5.06 ± 1.50	17.78 ± 4.91	1.04 ± 1.93
	KOCA	3	25.77 ± 15.45	4.87 ± 2.38	4.50 ± 0.95	35.13 ± 14.18	23.23 ± 15.85
	Total	11	13.32 ± 10.29	3.00 ± 2.14	4.66 ± 1.56	20.79 ± 11.55	6.23 ± 12.93



(a)



(b)

Figure 3.2-17 Distribution of the nest percentages due to the distance groups to sea and vegetation

(a) Percentages of the nests relative to distance from the sea

(b) Percentages of the nests relative to distance from the vegetation

3.2.1.6 Calculation of Nesting Females

Female numbers were estimated by dividing nest numbers by two for loggerhead turtles and three for green turtles [216]. By this calculation in the 2013 nesting season on METU-IMS beach there were 13 loggerhead nesting females and 4 green turtle females. Following the same assumption, it was calculated that 2280–2787 loggerhead turtles nest annually in the Mediterranean shown in Table 3.2-11.

Table 3.2-11 Calculation of nesting females.

Species	**Assumption 1** [216]	**Assumption 2** [241]
Caretta caretta	*26/ 3 = 9*	*26/ 2 = 13*
Chelonia mydas	*12/ 3 = 4*	*12/ 3 = 4*

On the basis that each female nests on average three times per season every 2-3 years [241] approximately 9 loggerheads and 4 green turtle females nested on METU-IMS Beach in the 2013. Based on the same assumption it was estimated that 2000 *C. caretta* females are nesting annually in the Mediterranean shown in Table 3.2-11.

3.2.1.7 Morphometric Measurements and Avarege Clutch Size

In the 2013 nesting season during the monitoring studies, a total of 35 female carapacial morphometric measurements were taken consisting of 20 for loggerhead and 15 for green turtles. In

Table 3.2-12 averages and ranges of all measurements are given. SCL and SCW represent the straight measurements taken by large wooden calipers, while CCL and CCW denote the curved measurements taken by elastic measuring tape.

Table 3.2-12 Nesting female carapacial morphometric measurements

Species		***Caretta caretta***	***Chelonia mydas***
N		20.00	15.00
SCL	**Av. ± St. Dev**	70.10 ± 3.37	82.07 ± 3.97
	Min.	63.00	77.00
	Max.	77.00	90.00
SCW	**Av. ± St. Dev**	52.25 ± 3.08	65.07 ± 4.01
	Min.	49.00	60.00
	Max.	56.00	66.00
CCL	**Av. ± St. Dev**	74.25 ± 3.60	85.53 ± 3.29
	Min.	69.00	82.00
	Max.	81.00	92.00
CCW	**Av. ± St. Dev**	64.45 ± 3.97	74.80 ± 3.73
	Min.	58.00	71.00
	Max.	70.00	80.00

According According to the averages obtained from the 2013 nesting season females, green turtles were larger all aspects. In the 2013 nesting season on METU-IMS Beach the average clutch size was 81.46 ± 14. 45 for loggerheads and 93.25 ± 11.99

for green turtles. Mean clutch sizes vary greatly from year to year and from beach to beach.

3.2.1.8 Incubation Duration and Temporal Distribution of Hatching Time

From Table 3.2-13 it is seen that the average incubation duration was 57.16 days (range 43.00-86.00) for loggerheads and 58 days (range 49.00-76.00) for green turtles.

Table 3.2-13 Incubation Duration periods among species for each zone

Species	Zone	N	min.	max.	average	STDEV
Caretta caretta	METU	19.00	43.00	86.00	57.21	11.75
	KOCA	4.00	48.00	64.00	56.50	6.61
	LIM1	2.00	54.00	62.00	58.00	5.66
	LIM2	0.00	-	-	-	-
	Total	25.00	43.00	86.00	57.16	9.37
Chelonia mydas	METU	8.00	49.00	70.00	58.75	8.01
	KOCA	3.00	50.00	50.00	50.00	0.00
	LIM1	1.00	76.00			-
	LIM2	0.00	-	-	-	-
	Total	12.00	49.00	76.00	58.00	9.39

This table includes all nest data from which at least one hatchling emerged. 3 loggerhead and 2 green turtle nests that were close to the sea but not washed away produced the outlier values overly increase the averages. When these outlier data were excluded, the relation of incubation duration with nest depth and distance to the sea changed to give mean incubation durations of 54. 96 for loggerheads and 56. 36 for green turtles. The maximum nesting crawls observed in June for both species resulted with a peak number of nests which began to hatch in August. Monthly distribution of the beginning of the hatching period for each species can be seen in Figure 3.2-18.

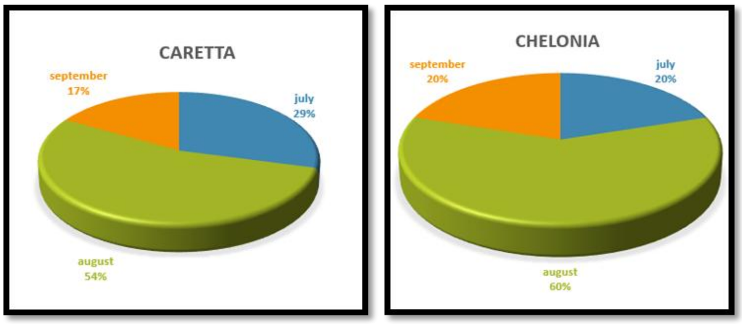


Figure 3.2-18 Temporal Distribution of hatching time for each species along METU-IMS Beach in 2013

3.2.1.9 Hatching Success

According to our results, a total of 2759 hatchlings emerged (hatching success: 80 % of total number of eggs), of which 2573 hatchling were able to reach the sea in the 2013 nesting season on METU-IMS Beach for both species as seen in Figure 3.2-19. Specifically for each species, 1650 loggerhead hatchlings emerged (hatching success: 77.10 % of total number of eggs) of which 1584 hatchling were able to reach the sea. Following loggerheads, a total of 1109 green turtle hatchlings emerged (hatching success: 84.98 % of total number of eggs), of which 989 hatchlings were able to reach the sea.

Table 3.2-14 Survival conditions of eggs for each species and for both species at METU-IMS

	loggerhd	%	green	%	Both	%
hatchlings	1650	77.10	1109	84.98	2759	80.09
Early embryos	46	2.15	50	3.83	96	2.79
Middle Embryos	50	2.34	3	0.23	53	1.54
Late embryos	210	9.81	55	4.21	265	7.69
Unfertilized eggs	103	4.81	48	3.68	151	4.38
Remained-dead in nest	33	1.54	60	4.60	93	2.70
predated after hatching	41	1.92	0	0.00	41	1.19
infected-abnormal eggs	7	0.33	3	0.23	10	0.29
Total number of eggs	2140	100.00	1305	100.00	3445	100.00

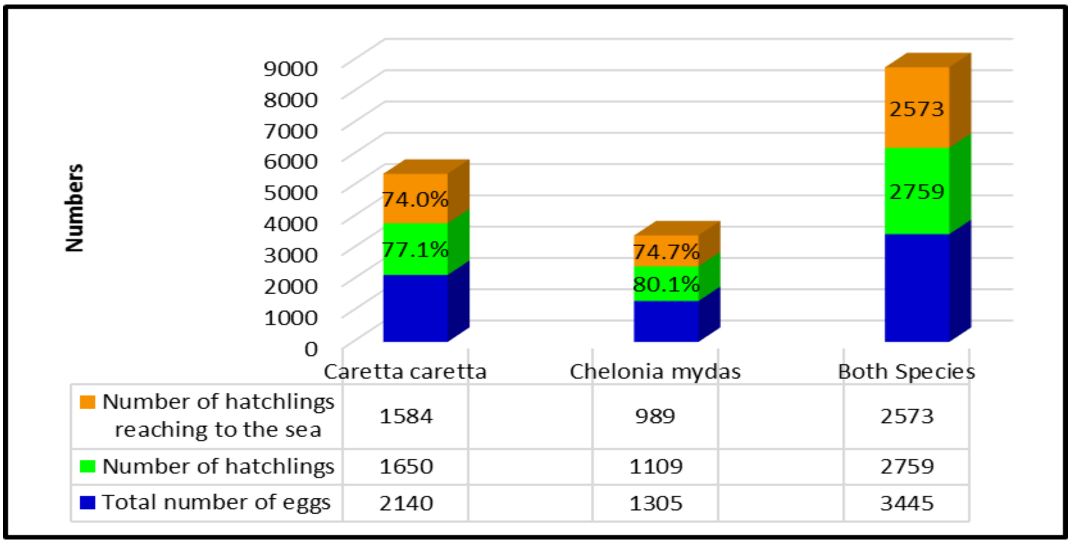


Figure 3.2-19 Comparison of the total number of eggs, hatchlings and hatchlings reaching the sea at METU-IMS

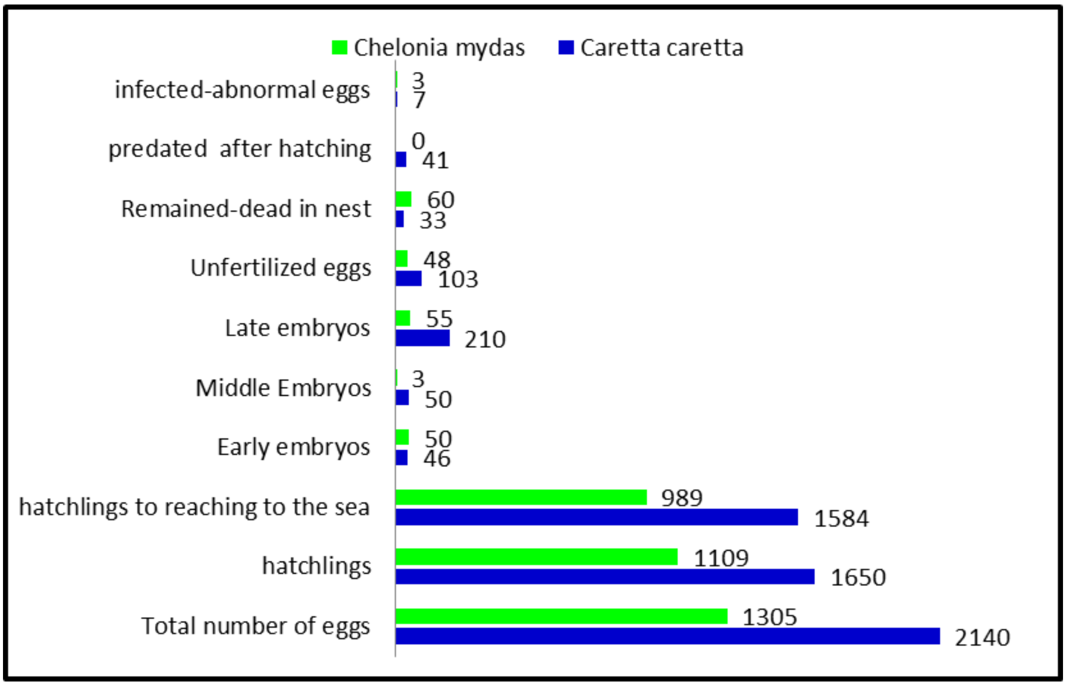


Figure 3.2-20 Survival conditions of eggs for each species at METU-IMS

There were also other groups classified as, early embryo, middle embryo, late embryo, unfertilized egg, remained-dead in nest, predated after hatching, and infectedabnormal eggs summarized in Table 3.2-14 and in Figure 3.2-19. The reason for the high number of loggerhead late embryos was due to a flood just 10 days before expected hatching time which adversely affected two nests.

3.2.1.10 Nest Parameters

In this section some of the environmental conditions which are thought to be used by nesting turtles as cues and also related to hatching success due to enhanced incubation period are presented. The physical characteristics of the METU-IMS beach covering moisture content, temperature, nest depth-diameter, incubation, distance from sea and vegetation and their relation to hatching success are given in the discussion. The results for depth, diameter and nest humidity of each species distributed along the zones are given.

- **Depth**

The average nest depth for loggerheads was 57.06 cm and 66.17cm for green turtles in the 2013 nesting season along METU-IMS. For loggerheads the deepest nests were located in the LIM1 sub region, followed by; KOCA and METU sub regions. For green turtles the deeper nests were found in the METU sub region compared to KOCA sub region as summarized in Table 3.2-15.

Table 3.2-15 Nests depth for each species distributed along the sub-regions in 2013 on METU-IMS Beach

Species	Depth					
	Zone	N	min.	max.	avr.	STDEV
Caretta caretta	METU	20.00	34.00	80.00	55.70	11.45
	KOCA	4.00	61.00	74.00	63.25	7.41
	LIM1	2.00	52.00	75.00	63.50	5.66
	LIM2	0.00	-	-	-	-
	Total	26.00	34.00	80.00	57.46	11.30
Chelonia mydas	METU	8.00	63.00	88.00	71.00	7.86
	KOCA	3.00	50.00	50.00	58.67	3.06
	LIM1	1.00	50.00			-
	LIM2	0.00	-	-	-	-
	Total	12.00	49.00	76.00	66.17	9.85

- **Diameter**

The average nest diameter values were close together for each species; being 23.77 ± 2.58cm for loggerheads and 25.08 ± 2.47cm for green turtles in the 2013 breeding season on METU- IMS Beach.

Table 3.2-16 Diameter of the nest chambers for each species distributed along the sub-regions in 2013 0n METU-IMS Beach

Species	Diameter					
	Zone	N	min.	max.	avera	STDEV
Caretta caretta	METU	20.00	17.00	29.00	23.60	2.82
	KOCA	4.00	22.00	26.00	24.25	1.71
	LIM1	2.00	23.00	26.00	24.50	2.12
	LIM2	0.00	-	-	-	-
	Total	26.00	17.00	29.00	23.77	2.58
Chelonia mydas	METU	8.00	23.00	28.00	26.13	1.96
	KOCA	3.00	21.00	23.00	22.33	1.15
	LIM1	1.00	25.00			-
	LIM2	0.00	-	-	-	-
	Total	12.00	21.00	28.00	25.08	2.47

- **Humidity**

Table 3.2-17 Humidity of the nests for each species distributed along the sub-regions in 2013 on METU-IMS Beach

Species	Humidity					
	Zone	N	min.	max.	avr	STDEV
Caretta caretta	METU	20.00	10.75	37.02	16.43	7.06
	KOCA	4.00	10.32	21.91	15.71	5.53
	LIM1	2.00	9.72	11.24	10.48	1.07
	LIM2	0.00	-	-	-	-
	Total	26.00	9.72	37.02	15.86	6.65
Chelonia mydas	METU	8.00	10.75	17.56	13.60	2.42
	KOCA	3.00	8.19	10.20	9.41	1.07
	LIM1	1.00	11.19			
	LIM2	0.00	-	-	-	-
	Total	12.00	8.19	17.56	12.35	

Total nesting parameters for green turtles are given in Table 3.2-18 and for loggerhead turtles in Table 3.2-19 are given below.

Table 3.2-18 Nest parameters of green turtles in 2013 nesting season on IMS- METU Beach

Chelonia mydas								Hatching Success		
Incubation	Depth	Clutch size	Diameter	Distance_sea	Dis.gro	Humudity	Locatio	% ind.	%intra	%inter
76	50	82	25	15.70	2.00	11.19	LIM1	91.46	6.76	2.72
49	72	77	28	22.20	3.00	11.17	METU	77.92	5.41	2.17
51	70	99	27	23.60	3.00	10.75	METU	84.47	7.84	3.15
59	67	85	23	14.50	2.00	13.45	METU	85.88	6.58	2.65
58	63	95	24	16.30	2.00	11.81	METU	85.71	7.57	3.04
70	75	108	25	15.90	2.00	13.51	METU	87.70	9.65	3.88
65	65	116	28	18.80	2.00	14.13	METU	94.21	10.28	4.13
51	68	104	26	8.80	1.00	16.40	METU	97.12	9.11	3.66
67	88	98	28	16.40	2.00	17.56	METU	91.00	8.21	3.30
50	58	85	21	25.00	3.00	10.20	KOCA	74.71	5.86	2.36
50	62	87	23	26.80	3.00	9.85	KOCA	83.91	6.58	2.65
50	56	83	23	27.40	3.00	8.19	KOCA	81.93	6.13	2.46
58.00± 9.39	**66.17 ± 9.85**	**93.25 ± 11.99**	**25.08 ± 2.35**	**19.28± 5.69**		**12.35 ± 2.75**		**86.34**	**7.50**	**3.01**

Table 3.2-19 Nest parameters of loggerheads in 2013 nesting season on IMS- METU Beach

Caretta caretta								Hatching Success		
Incubation	Depth	Clutch size	Diameter	Distance_sea	Dis.gro	Humudity	Locatio	% ind.	%intra	%inter
62	52	59	23	27.80	3.00	9.72	LIM1	86.67	3.15	1.88
54	75	69	26	27.50	3.00	11.24	LIM1	33.33	1.39	0.83
43	40	95	19	14.00	2.00	13.80	METU	91.67	5.33	3.19
46	53	100	17	8.20	1.00	17.24	METU	97.00	5.88	3.52
61	58	85	25	16.50	2.00	12.59	METU	82.22	4.48	2.68
55	57	78	22	13.40	2.00	13.72	METU	88.46	4.18	2.50
58	65	63	28	13.80	2.00	14.68	METU	96.83	3.70	2.21
58	48	85	22	14.20	2.00	12.19	METU	90.59	4.67	2.79
56	55	86	23	19.30	2.00	12.73	METU	88.37	4.61	2.75
54	46	75	24	11.20	2.00	12.15	METU	89.33	4.06	2.43
51	50	67	24	11.60	2.00	16.22	METU	60.32	2.30	1.38
57	60	90	20	16.40	2.00	11.74	METU	96.67	5.27	3.15
58	52	61	23	18.00	2.00	10.75	METU	59.02	2.18	1.30
55	56	85	22	16.50	2.00	11.40	METU	98.82	5.09	3.04
52	52	80	24	16.30	2.00	11.20	METU	98.75	4.79	2.86
62	72	105	25	14.40	2.00	17.18	METU	93.33	5.94	3.55
58	78	66	25	11.20	2.00	19.50	METU	92.42	3.70	2.21
44	34	82	25	14.40	2.00	10.75	METU	91.46	4.55	2.72
54	80	78	29	14.40	2.00	17.65	METU	88.75	4.30	2.57
48	61	104	22	33.20	3.00	10.32	KOCA	62.04	4.06	2.43
58	61	100	26	11.50	2.00	18.77	KOCA	94.00	5.70	3.41
56	57	101	24	15.60	2.00	11.84	KOCA	85.58	5.39	3.23
64	74	92	25	9.40	1.00	21.91	KOCA	88.04	4.91	2.94
WASHED	58	55	26	10.90	2.00	37.02	METU	0.00	0.00	0.00
86	47	81	24	15.00	2.00	25.00	METU	3.70	0.18	0.11
79	53	76	25	11.30	2.00	31.15	METU	3.90	0.18	0.11
57.16± 9.37	**57.46 ± 11.08**	**81.46 ± 14.45**	**23.77 ± 2.53**	**15.62 ± 5.70**		**15.86 ± 6.52**		**75.43**	**3.85**	**2.30**

- **Temperature**

In the 2013 season, temperature profiles for the total incubation period were obtained from two loggerhead nests, another profile only showed the first third of incubation due to insufficient battery power of the device caused by a logger activation error. For those showing the whole incubation period, the middle third of incubation duration which is critical for sex determination is given separately. In Figure 3.2-21 the profile of LGR S/N: 10096406 logger is given. Red line indicates the beginning of hatching time.

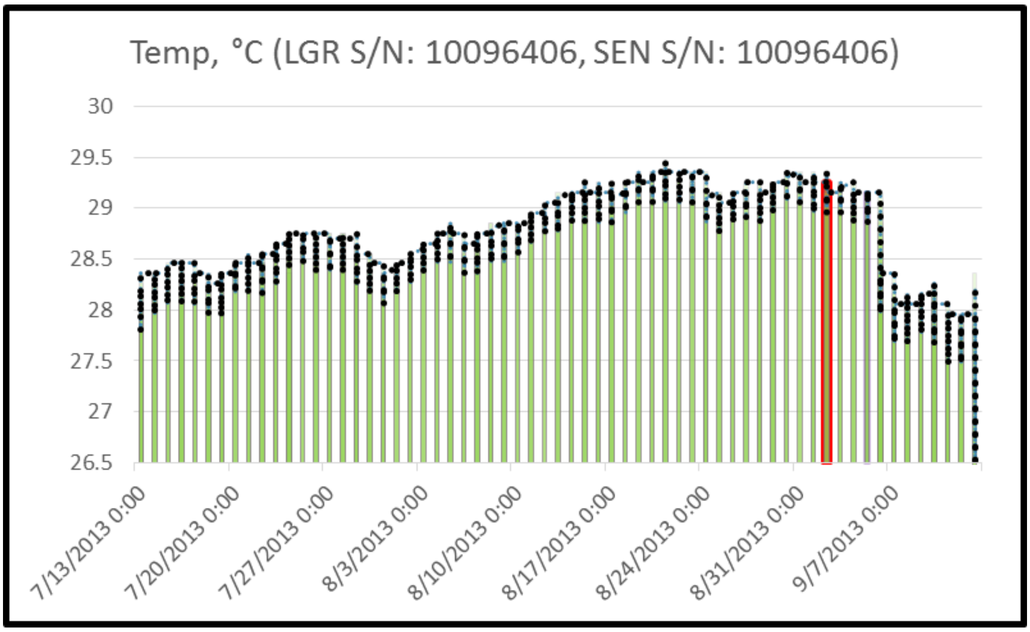


Figure 3.2-21 Temperature profile of LGR S/N: 10096406 logger

Mean temperature for the duration of incubation for LGR S/N: 10096406 logger was 28.66±0.57 °C.

In Figure 3.2-22 the profile for the middle third of incubation for LGR S/N: 10096406 logger is given.

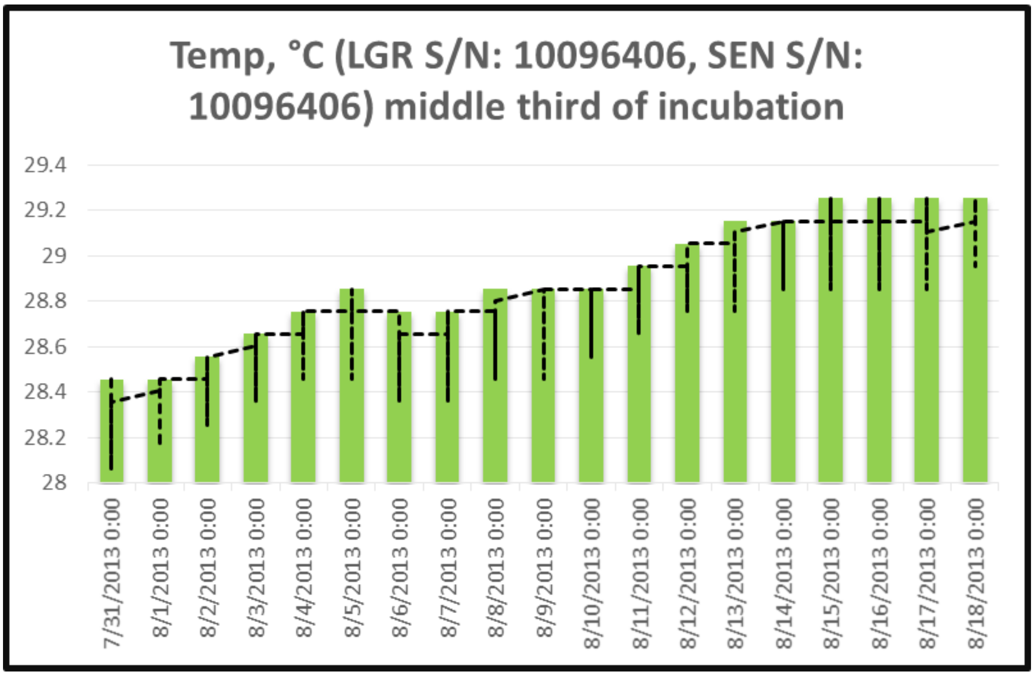


Figure 3.2-22 Temperature profile of middle third incubation duration for LGR S/N: 10096406 logger

In Figure 3.2-23 the profile of LGR S/N: 10209545 logger is given. Red line indicates the onset of hatching.

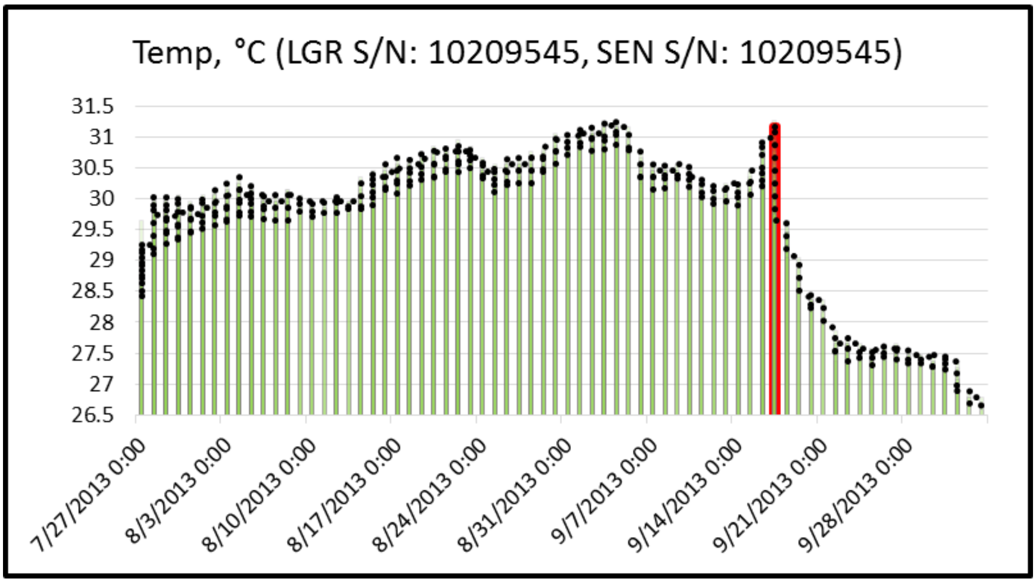


Figure 3.2-23 Temperature profile of LGR S/N: 10209545 logger

Mean temperature for the duration of incubation for LGR S/N: 10209545 logger was 29.63±1.21 °C.

In Figure 3.2-24 the temperature profile for the middle third incubation duration for LGR S/N: 10209545logger is given.

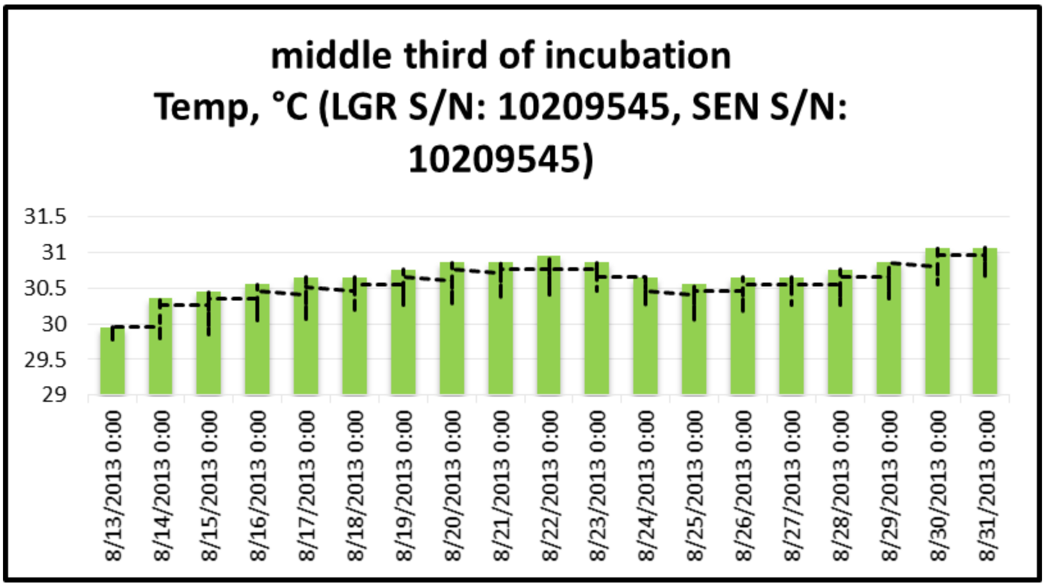


Figure 3.2-24 Temperature profile for the middle third of incubation for LGR S/N: 10209545 logger

The sex determinant period differed with average temperatures throughout the incubation duration. For the middle third of incubation duration of LGR S/N: 10096406 logger mean temperature was 28.73±0.27 °C. It is seen that when this period of incubation was compared with the entire duration, higher average temperature values with lower standard deviations were recorded as expected For the middle third of incubation of LGR S/N: 10209545 logger the mean temperature was 30.46±0.30 °C covering the second half of August having higher values than LGRS/N: 10209545 which covered the beginning of August.

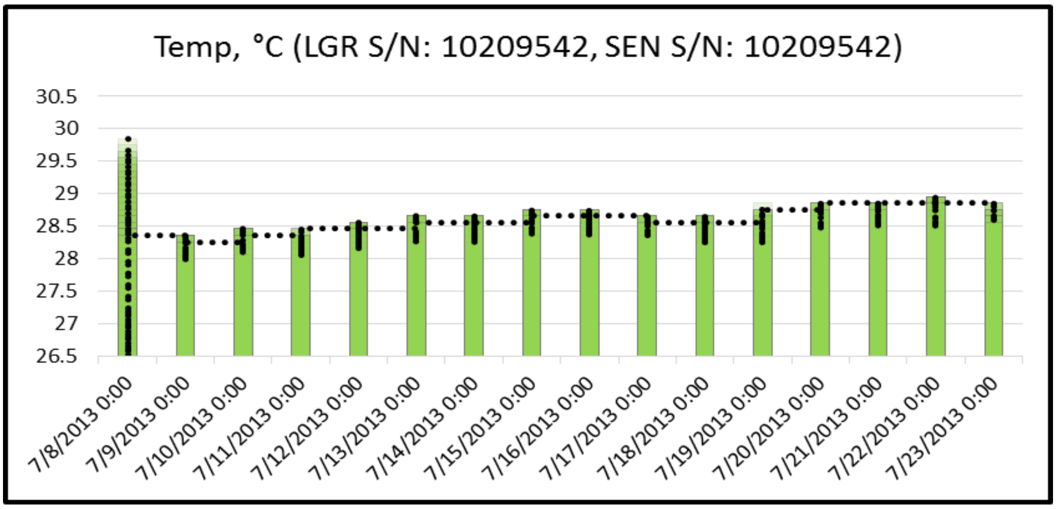


Figure 3.2-25 Temperature profile of LGR S/N: 10209542 logger

Unfortunately, data for LGR S/N: 10209542 logger was insufficient to evaluate the nest situation. However, values for approximately the whole of July were available. The other two devices provided temperature recordings for August. Between 8th of July and 23th of July in 2013 the average sand temperature was 28.48 ±0.27 °C.

3.2.2 Nesting Activities Monitored by Camera-Laser Beam System

With this system, several important aims were carried out with the monitoring and conservation project that helped us to obtain more data about the nesting tendency of these two species of sea turtles and to develop new monitoring methodologies which have proved to be a great asset in patrolling activities and data collection. The primary alarm system including active infrared laser beam sensors coupled with the alarm system was integrated with a call center to alert the researcher. This call center named as “Güvenli Hayat Alarm Takip Merkezi” “Reliable alarm tracking centre” sent monthly reports on each alarm call with date, time and zone. Initially, data was filtered with time and condition of the alarm. Throughout the field study, the system was tested numerously, and data produced by false alarms (triggered by reseachers mistakenly passing through the sensors) was accounted for. Due to these factorss, only data from 20:00 to 07.00 was taken into consideration and nonsense alarms were also filtered. After fitration of data, where certain types of signal were classified as nonsense, emerging turtles and returning turtles were classified specifically for each turtle. Detection of turtles was the expected outcome so each alarm detecting a turtle was coded as true (the number), either during emergence orreturn. But unfortunately, there were also other cases where alarms were incorrectly activated coded as false alarms (number). A nonsense code was given for system construction, calibration and regular test alarms. The results showed that the laser beam system tailored from security systems detected 85.71% of nesting female emergences with 14.71% false alarms. However, testing of the laser system showed that other land animals such as wild dogs, cats and foxes, triggered false alarms therefore possibly causing interference of these detection activities. Such interference problems could be solved by applying deterrentssuch as repellents or ultrasound. Since this was the pilot project for the laser system, it was installed only on one section of the beach, therefore further studies need to be carried out to improve this useful monitoring methodology. A secondary alert system with infrared motion sense cameras and recorder could also be also to individually identify the reasons causing the false alarms.

Figure 3.2-26 Image of at female nesting turtle identified by the camera system

Despite these inaccuracies, the main goal of employing this systemnotably the detection of the exact location of the sea turtles alerted by detectors was achieved. The camera and laser beam systems undoubtedly proved to be extremely useful and accurate in both the detection and identification of sea turtles on the beach. In particular, these technologies have demonstrated that it is possible to reduce human effort in terms of beach patrolling whilst at the same time increasing accuracy in data collection as seen in Figure 3.2-26. Night vision cameras enabled researchers to identify several sea turtles which could not have been reached in time during patrols, especially in the monitored areas devoid of the laser beams. The biggest problem that was faced in the 2013 nesting season was the incompability of hard discs with the recorder. So all the documentation that motion sensitive cameras sent to the recorder were missed. Only some of the recordings were saved seen in Figure 3.2-26. For this reason the percentage of true and false alarms or the percentage of identified nesting female locations could not be given. On the other hand assessing the benefits of the automated system further, the monitoring of nests close to hatching could supply valuable information on hatchling success, behavioral observations, and the existence of any kind of predation. An example from a green sea turtle nest was investigation for emergence behavior of hatchlings to better understand the dynamics of hatching with the aim of enhancing green sea turtle protection. Hatching was observed to continue for 17 days following the first emergence. Analysis of the video recordings revealed that group dynamics and social facilitation seemed to play an important role in leaving the nest, although not all hatchlings emerged synchronously. The observed asynchrony in the emergence of hatchlings highlighted the importance of leaving an extended period before excavation of the nest after the peak emergence activity. The majority of hatchlings emerged during the night, avoiding high temperatures and increased predation risk during daytime.

3.3 Stranding Activities

Data on stranding activities of dead loggerhead and green turtles were collected from the study region and its surroundings via calls and regular patrols during the nesting seasons between 2011 and 2014. A total of 19 turtle strandings summarized in Table 3.3-1were recorded for 15 loggerheads and 4 green turtles. A total of 56 calls were directed to the rehabilitation center without any visual data due to their long distances from the study region. It can therefore be stated that 75 stranding were recorded by researchers at METU-IMS. The curved carapace lengths (CCL) of loggerheads ranged from 55-99 cm (mean 69.90±13.84) and CCL of green turtles ranged from 25-78 cm (mean 43.67±29.77). Other morphometric measurements are given in Table 3.3-1 with mean values in Table 3.3-2. 50% of loggerheads were juvenile (30≤ cm CCL≤70), the remaining 50% were adults (≥ 70cm CCL).

Table 3.3-1Stranding turtle data from 2011 to 2014

#	Date	Sp.	CCL cm]	CCW [cm]	SCL [cm]	SCW [cm]	Location
1	29.03.2011	C C	58	46	55	41	ODTÜ
2	27.04.2011	C C	73	64	69	53	
3	28.03.2012	C C	99	68	87	61	Erdemli/Cesmeli
4	10.04.2012	C C	76	67	71	56	Erdemli/Kargipinari
5	26.01.2013	C M	28	14	24	11	ODTÜ
6	27.01.2013	C C	56	45	53	38	Mezitli
7	17.04.2013	C C	61	46	55	40	Kocahasanli
8	14.05.2013	C M	25	13	21	10	Limonlu
9	05.06.2013	C C	55	46	49	42	ODTÜ
10	30.08.2013	C M	78	64	73	59	Kazanli
11	30.12.2013	C C	-	-	-	-	Erdemli/Arpacbahsis
12	03.04.2014	C C	76	64	70	60	Limonlu Beach
13	07.04.2014	C C	81	68	77	64	ODTÜ Harbor
14	28.04.2014	C C	-	-	-	-	Limonlu Beach
15	10.05.2014	C C	-	-	-	-	Erdemli
16	10.05.2014	C M	-	-	-	-	Erdemli
17	12.05.2014	C C	-	-	-	-	Erdemli
18	13.05.2014	C C	-	-	-	-	Limonlu Beach
19	14.05.2014	C C	64	47	59	42	ODTÜ/Llimonlu
	C C: *Caretta Caretta, C M: Chelonia mydas*						

Table 3.3-2 Average carapace measurements of stranding turtles for each species

		CCL [cm]	CCW [cm]	SCL [cm]	SCW [cm]
Chelonia mydas	Average	43.67	30.33	39.33	26.67
	ST.DEV	29.77	29.16	29.19	28.01
Caretta caretta	Average	69.90	56.10	64.50	49.70
	ST.DEV	13.84	10.74	12.20	10.08

Table 3.3-3 Visual Records of Stranding Turtles from 2011 to 2014

Date	Species	Date	Species		
29.03.2011	*C C*	27.04.2011	*C C*	28.03.2012	*C C*
					
10.04.2012	*C c*	26.01.2013	*C m*	27.01.2013	*C c*
					
17.04.2013	*C c*	14.05.2013	*C m*	05.06.2013	*C c*
					
30.08.2013	*C m*	03.04.2014	*C m*	14.05.2014	*C C*
					

On the other hand, 66.67% of green turtles were small juveniles (≤31.5 cmCCL), and 33.33% were juvenile (31.5≤ cm CCL≤85). From 13 measurements we obtained 12 visual records. The reason for one missing record was the absence of a camera or phone when the turtle was noticed represented in Figure 3.3-3. The carcass of a green turtle (*Chelonia mydas*) was found on the beach at the Institute of Marine Sciences of the Middle East Technical University located at Limonlu in the province of Mersin on 14th May 2013. It was discovered by one of the researchers at the institute where there are ongoing sea turtle monitoring studies. The specimen was a juvenile in an advanced state of decomposition, and had died approximately two weeks earlier.

Figure 3.3-1 External view of dead *Chelonia mydas* juvenile

Curved measurements were 30 cm for length and 26 cm for width, while straight measurements were recorded as 28 cm for length and 25 cm for width. After external examination and visual data collection as shown in Figure 3.3-1, to understand the reasons for the death of the juvenile green turtle, a detailed necropsy was carried out. Despite the decomposition of the carcass, the internal organs were found to be largely intact, particularly the gastro -oesophageal tract and the entire digestive system. Careful analysis of the stomach contents and the primary section of the intestine have provided data to support that the animal had been in good health as it appeared that its main food, consisted mainly of marine plants showing normal nutritional activity This indicates that the animal had no signs of illness when alive because she continued to feed until the time of death. However, analysis of the terminal section of the intestine and colon revealed intestinal obstruction caused by the accumulation of residues of rigid plastic from 1 to 3 cm in size, as well as fragments of balloons (composed of latex and polychloroprene). The balloons particularly drew our attention, as one of them was almost completely intact and another clearly read the Mc Donald’s M logo, of the fast-food multinational corporation as can be seen in Figure 3.3-2. After establishing the cause of death, the plastic waste found has been preserved and photographed to be subsequently washed and analyzed in the laboratory for further investigation. The foreign objects removed from the intestinal tract of the dead turtle are shown in the photos below (Figure 3.3-3).

Figure 3.3-2 Plastic fragments removed during necropsy

Figure 3.3-3 Total plastics parts organic materials were removed

The turtle carcass was then buried in a pit dug 5 m away from where the animal was found, at a depth of 1, 5 meter. Juvenile green sea turtles feed mainly on algae and jellyfish before their diet shifts to mainly vegetarian mainly in the adult stage. Unfortunately their preference for jellyfish can lead to the unnecessary deaths of many turtles as in the case described above. Sea turtles often mistake floating debris such as plastic bags and balloons (because of their neutral buoyancy in water) for their favorite food items (jellyfish). Following ingestion these floating plastics cause death by either poisoning or intestinal obstruction, as seen in the above case. Considering the need of 20-30 years for sea turtles to reach adult maturity it is easy to realize the magnitude of the appalling effect which environmental pollution caused by plastic and its derivatives has on these gentle sea creatures. The general public should be alerted to all the many similar cases that occur every year in turtles and other marine animals. There must be greater awareness campaigns on the theme of marine pollution, and the devastating damage that it causes not only to the entire marine ecosystem but ultimately to biodiversity as a whole. Another striking cause of death detailed in this study was entanglement of a fish hook in the esophagus of a *Caretta caretta* individual. After a call from Kocahasanli claiming there was a dead turtle on the beach on 17th April 2013 the specimen was located seen in Figure 4.3-4 and examination began with visual data collection and external observations.

Figure 3.3-4 External view of dead *Caretta caretta* juvenile

Curved carapace measurements were 62 cm for length and 53 cm for width, while straight measurements were recorded as 60 cm for length and 48 cm for width showing this loggerhead was a juvenile close to adulthood. The internal organs were found to be largely intact, particularly the gastro -esophageal tract and the entire digestive system although approximately ten days had already passed since the death of the animal. Careful analysis of the stomach contents and the primary section of the intestine have provided data to support that the animal had been in good health as it appeared that its main food, consisted mainly of shelled benthic animals showing normal nutritional activity.

Figure 3.3-5 Fishing line entangled in spiny esophagus

An abnormally large segment of intestine was observed containing a whole fish in two large pieces. Following the digestive tract, a piece of fishing line was noticed in the last section of the spiny esophagus. Along with the fishing line, a large entangled hook was found as seen in Figure 3.3-5. It was assumed that the turtle had attempted to eat the fish already captured by the fishing longline. While the turtle tried to masticate the fish by its beak, and via the contractions of the muscles around the esophagus, the hook became embedded in this region. After establishing the cause of death, the fishing line with the hook was preserved and photographed to be subsequently washed and analyzed in the laboratory for further investigation (Figure 3.3-6). The turtle carcass was buried in a pit dug 5 m away from where the animal was found, at a depth of 1.5 m. Improper fishing activities cause the death of sea turtles.

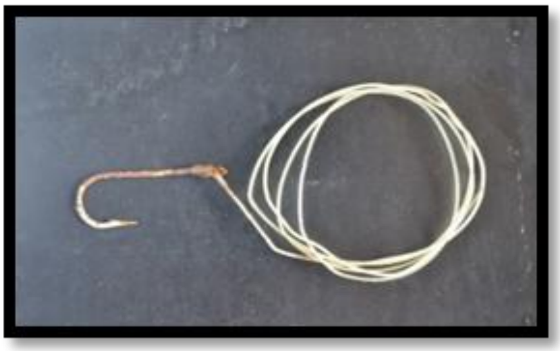


Figure 3.3-6 Whole fishing line after organic materials were removed.

3.4 Educational Training

In the scope of different projects, 7.350 primary school, 9.256 high school and college students and 869 undergraduate- post-graduate university students were informed. With the power of media and public informative studies calls about injured and dead turtles increased rapidly. In addition, primary school and high school students attending the institute within the scope of the TUBITAK Project entitled "I Know My
Sea, I Protect My Sea" were informed by visual presentation and to further increase impact field surveys and activities were held together as seen in Figure 3.4-1.

Figure 3.4-1 Training activities for primary schools, high schools and colleges

Schools and members of the public who wish to visit METU-IMS and be informed about the sea turtle activities and our Institute are welcomed. A group of foreign volunteers participating in a Youth Project exchange visit, patrolling another beach in Mersin attended a seminar on the turtle monitoring programme before a joint beach cleaning activity as seen in Figure 3.4-2.

Figure 3.4-2 Beach cleaning activity with Institute staff members and foreign visitors

Participants of summer and winter schools (undergraduate students) organized by METU-IMS also received training and attended our monitoring survey as shown in Figure 3.4-3.

Figure 3.4-3 Summer school students taking part in night-time beach patrolling

With the collaboration of Mersin University, school teachers were informed about the history, taxonomy, anatomy, sea life adaptations, life history, and nesting ecology of sea turtles. The importance of first informing teachers is the possibility of reaching many students. Two workshops were also carried out to inform seasonal campers in the KOCA sub region and beach café users outside of the study region in Kocahasanli. All attendees were notify about the rehabilitation center in Mersin, and the call number in the case of emergency for a turtle. Moreover, we maintained constant contact with regional and national journalists (Figure 3.4-4) to emphasise especially in the tourist season the increase in detrimental usage of the nesting areas, water and beach pollution, artificial light usage, light activities along the beaches at night and in some cases people causing deliberate harm to the nesting turtles and hatchlings.

Figure 3.4-4 Informative studies done with the collaboration of media

Figure 3.4-4 Informative studies done with the collaboration of media

Finally, a web-site was created to increase the number of people accessed covering general information on sea turtles and an interactive map so that the exact location of the turtle spotted could be determined as well as providing optional extra information and pictures. The usage of the web- site was one of the topics of presentations for the visitor schools and the link is found on the main page of the institute website, www.ims.metu.edu.tr. Sample snapsot views of the web page can be seen in the Figure 3.4-5.

Figure 3.4-5 METU-IMS Sea Turtle Website

3.5 Genetic Barcoding

A perfect match (100% similarity) was found with respect to the cox1 barcodes between Turkey and Greece *Caretta caretta* samples also, 99% similarity were observed between all others. According to Kimura 2-Parameter model, the distance between Turkish and Greek *Caretta caretta* samples is 0,000; Turkey and Gene bank mined sample (CYTC5514-12) 0,002 and 0,008 value was observed between all others. It is clearly seen that the Turkish samples are located between the U.S. and Australian samples. This is the first time that the Turkish coast samples have been barcoded. A total of two *Caretta caretta* specimens were observed in the present study. Stop codon was not detected. The full K2P/ML (Maximum Likelihood) tree has been lodged as Figure 3.5-1.

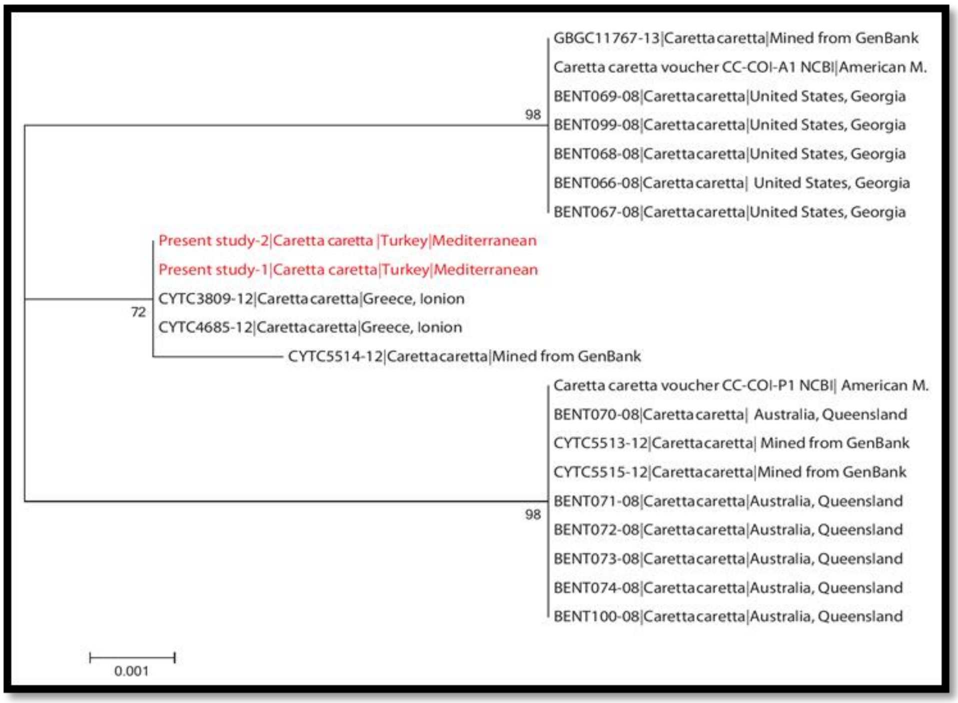


Figure 3.5-1 K2P/ML (Maximum Likelihood) tree

CHAPTER 4

DISCUSSION

4.1 Ecological Characteristics of the Study Area

Firstly, the results of the ecological parameters of the study area emphasize the importance of suitable nesting site selection by females for proper embryo development and hatching success [217]. Undoubtedly, higher survival of the offspring reflects higher fitness for parents [218]. In this section, ecological parameters collected during the 2013 nesting season from METU-IMS beach are discussed to relate them to survival rate success, successful embryo development and parental fitness covering possible external environmental clues used for nest site selection. Secondly, results of nesting activities are discussed in relation to the comparable aspects of two different methodologies and data from the nearest official nesting sites. Results of the two different monitoring methodologies, links between them and reliability of the new system are discussed. Thirdly, reported stranding events allow us in this chapter to discuss in particular two different causes of death. The efficiency of the educational studies are also discussed in this chapter. Finally, the initial promising results from the genetic analyses and tracking device are deliberated as future work.

4.1.1 Ecological environmental parameters

Boundary Parameters

Throughout the 2013 nesting season there were many fake crawls where individuals attempted to pass through the wall and immediately returned back to the sea in the LIM2 sub region. On the contrary, all fake crawls in LIM1 resulted in at least one body pit. The closest man-made physical structures here were 52 meters distance from the sea. The METU sub region displayed high values of nesting and hatching success percentages with the nearest structure being 44 meters from the sea. The KOCA subregion contains a variety of man-made structures positioned close to the sea namely holidaymakers tents, a shop, WC-Shower facilities, as well as presence of intense artificial lighting, noise and unrestricted usage of the beach. When we consider the data, it is clear that the frequency of Green turtle nests increased from west to east hence their nest numbers increase through the KOCA subregion. Another notable result is that, Loggerhead nests are positioned on average at a distance of 14.71 meters from the sea, while for Green turtles that value is 20.79 meters. It can therefore be said that Green turtle nests are located on average further from the sea. Based on the results obtained for the 2013 nesting season in the METU-IMS study area, we can state that the critical average distance from the sea with the absence of physical barriers should be at least 17.75 meters. Also when we consider that the nesting crawl path is longer than the actual distance of nest position, the average critical zone could be determined as 20.00 meters therefore both LIM1 and KOCA subregions fall below this value. Moreover, since Green turtle females more frequently emerged towards the east it may be said that the critical value could be determined with increasing order from west to east. With respect to nesting success rates of both species amongst the sub-regions, the highest rates were shared by the METU and KOCA sub-regions underlining the suitability of the ecological features and sand characteristics of those sub-regions. Rapid urbanization brings other problems such as the influx of many more people to the area who are oblivious to the harmful environmental impacts as a result of incorrect usage of the beaches due to the lack of education and informative studies. Despite the presence of a camping site, the KOCA subregion has one of the highest nesting success rates for both species which emphasises the importance of properly conducted monitoring strategies and educational activities.

Beach Profiles.

The profiles that we obtained provide information on elevation, slope and width parameters. Successive profiling studies also enable us to understand how the beach environment constantly changes which could increase survival rates of hatchlings and fitness of the adults. The beach slope influences both the female trying to ascend to the top of the beach and the new hatchlings crawling seawards. Successful hatching is correlated with nest elevation offering a higher chance of nest survival based on more isolation and protection from tidal inundation. This is supported by the information that the slope is the most important factor influencing nest site selection in Loggerhead turtles [218]. Other studies found beach length to be negatively correlated and beach height positively correlated with nesting beach selection [242]. In summary, shorter and higher beaches are preferred by Loggerhead turtles. Loggerheads nest on ocean beaches, generally preferring high energy, relatively narrow, steeply sloped, coarsegrained beaches. Studies have shown that Green turtles tend to place their nests at elevations between 1-3 m [243]. These findings agree with the present study as the METU and KOCA sub regions with average elevations of 1.2 meters displayed higher nesting success rate values of Green turtles than for the LIM2 and LIM1 sub regions despite far greater average elevation values. Given the higher elevation values at the sub-regions of LIM2 and LIM1 it was expected to find a much higher Loggerhead nesting success rate than was the case for the nesting season in 2013. However, it is important to remember that nest site selection is a multifactor process affected by both internal physiological and external environmental parameters. Although the ideal elevation values occurred at sub-regions LIM1 and LIM2, METU and KOCA displayed a higher nesting attempt percentage, nest density and nesting success values. Some of the reasons behind this could be: the Lamas River in LIM2 mainly affects humidity, the substrate characteristics of LIM1-LIM2 exhibited much larger sized grain particles than those of the METU-KOCA sub regions and were less sorted in composition. The beach elevation study reveals that the camping activities of the KOCA sub-region reduce the suitability of this as a nesting beach by 25.62%. This result reflects only the presence of humans. Other uncountable factors such as crowdedness, artificial lights, and loud noise obviously dramatically decrease this further. For these reasons, legislations that forbid all construction not adhering to a specified distance from the sea must be strictly applied. To educate the general public, informative projects must be widespread which are designed in accordance to the target age groups. Also, trained personnel on hand at the nesting beaches could control conditions of the beach and help to inform and educate beach-goers.

Sand Softness:

It is possible that nourished beaches result in lower numbers of nesting females per season or affect egg chamber temperatures, effectively altering sex ratios [244]. Studies have shown that sea turtles prefer areas with softer, looser sand for their nests [224]. Softer sand makes it easier for the female to excavate the chamber and easier for the hatchlings to reach the surface of the beach after hatching from their eggs. Another parameter behind the lower success of LIM1 and LIM2 sub regions compared to the METU-KOCA sub regions for Loggerheads, after beach elevation and width, could be sand softness since digging a nest in harder substrate requires even more energy. Additionally it is harder for the new hatchlings trying to reach the surface. Sand compactness further has an impact on gas diffusion which directly affects embryonic development and hatching success and is discussed under the topic of humidity.

Sand Composition:

Literature seach showed that studies were debating on whether sand preferences and nesting placements were correlated or not [219] [243]. There were studies including a broad variety of forms, from darker to lighter colours, from calcareous to igneous origin and from the finest particle sizes to coarse shells or coral pieces [243]It has been shown that the influence of the above parameters is species specific and that coarsegrained beaches present difficulties for Green turtles during nest excavation and that nest placement attempts were consequently aborted [219]. Surprisingly it was recorded from Florida that, Loggerhead turtles tend to nest in areas with coarse-grained sand composed of calcium carbonate shell fragments [218]. Studies from Turkey indicated mean particle size of 350 μm (fine-medium sand) at the nesting sites of Green turtles and smaller sizes at non-nesting sites [245]. Other studies with Loggerhead turtles documented sand particle sizes ranging from fine to medium well-sorted grains at the nesting beaches of Greece [246]. It is generally agreed that the overall nesting success for Loggerhead turtles is related to a combination of factors together with low levels of human disturbance and good sand conditions. Due to the tendency of turtles avoiding nesting in areas with stones and pebbles, the access to the beach could be difficult as well as the excavation of a nest [247]. Due to the high divergence between the needs and preferences of different species it is difficult to conclude sand particle size as a nesting factor affecting selection although its influence on embryonic development and hatching success is obvious. In this study, the METU sub region is mainly composed of very fine sand (125 μm) and fine sand (250 μm) which displayed a higher hatching success rate than the LIM1 sub region composed of a wider range of grain size classes namely very coarse sand (2mm), coarse sand (1 mm), medium sand (500 μm), very fine sand (125 μm) and fine sand (250 μm). Rounding shows the degree to which a clast has had its edges and corners worn and could indicate energy conditions during transport and deposition as with grain size. The fact could be used as a clue that the farther a clast travels the more rounded it becomes. In this study at the METU sub region, the sample particles were sub rounded and well-rounded as opposed to the LIM1 sub region sample particles which were a mixture of sub-angular, sub-rounded and wellrounded particles. The Lamas River close to LIM1 strengthened by the general current regime in an east-west direction along the Cilician coasts [248] could carry particles through the LIM1 sub region but the existence of the harbor may affect their movement resulting in deposition on the beach before travelling longer distances. By selective transport and deposition, sediments of particular sizes as a result of changes in energy are sorted to a particular degree. The results from this study depict particles to be well sorted for the METU sub region and poorly sorted for the LIM1 sub region.

Vegetation

According to the literature, the preferences of both Green and Loggerhead turtles are areas containing supralittoral vegetation [244]. But a decrease in distance between vegetation and nests could increase the risk of obstruction by growing roots and/or posing problems for chamber excavation [218]. Another theory is that thick vegetation or material deposited on the beach and being washed ashore by currents and wind together with land based items could reduce the hatchling success [249]. In this study there is no case that vegetation created a problem for hatchlings, but one nesting female had difficulty with nest chamber digging due to the strong roots of a woody plant found at the border of the METU sub region. Moreover, it is observed that the existence of sand lilies provide stabilization of the sand thus increasing beach elevation in time and supporting successful succession.

4.1.2 Insect Survey

Phaleria acuminata is mainly present in the wet sand zone. In this study *P. acuminata* was recorded in 5 samples all of which were in the wet sand zone. The Genus *Phaleria* require a specific sand moisture content, organic content in some cases and also grain size [250]. It is also important that *Phaleria* species are good bio-indicators of the health of beach ecosystems [250].

Tenebrionid (Darkling beetles) were found in all six samples, but within each sample only across 3 micro habitats: Dry sand, Vegetation 1 *Pancratium maritimum* and Vegetation 2 *Salsola kali. Tenebrionid (*Coleopteran*:* Tentyriidae*)* mostly dominated in the dry sand zone followed by presence in Veg. 1 and Veg.2 respectively, this appears to be the case since (from personal observation) the small *Tenebrionid* spent most of their time under the sand. The *Tenebrionid* family include "many species of which feed on plants remains and living or dead roots" [251].

Erodius siculus, , was found mostly in sheltered zones which include Vegetation 1 *Pancratium maritimum,* Vegetation 2 *Salsola kali* and bushes (plants higher than 0.5m). These are flightless, slow moving beetles of which the larvae and adults are detritivours, although adults have been observed to feed on carrion and dung [252]. The larvae obtain their food and water from the roots of sand dune plants which allows them to successfully complete their development during hot periods [252]. Both species *P. acuminata* and *Tenebrionidae* play important roles in cycles of the ecosystem [253]. *Myrmeleon* Adult ant lions are nocturnal, have wings to fly short distances to find a mate and live short lives. In contrast, the ant lion larval development period is much longer than other stages of its life cycle, where it takes from one to two summer seasons to mature [254]. The ant lion larva has a unique method of capturing their prey creating a pit trap where they lie in the sand and only their head and mandibles are exposed [255]. The ant lion larvae have a unique method of capturing their prey by creating a pit trap where they lie in the sand with only their head and mandibles exposed [256]. Ant lion larvae during this survey were recorded in 2 zones which were open dry sand and sheltered Vegetation 2 (*Pancratium martimum).* It has previously been reported, [257]. That Ant lion larvae live in two different habitats, both open (unsheltered) and protected (sheltered). Open habitats are places like sand dunes which can be directly influenced by the suns rays, rain and wind [257]. Sheltered or protected habitats are where the ant lion larvae stay in an area where growth vegetation or other substrates exist which would protect them from environmental factors. Ant lion larvae from different regions like South Africa, Australia and Europe have evolved to exhibit different preferences to the size of sand. *Bucherillo litoralis* was found in three different zones; Vegetation 1 *Pancratium maritimum*, Vegetation 2 *Salsola kali* and bushes. They were found in the highest abundance in bushes which could be because they seek shelter from the sun, wind or rain. There have been no surveys conducted on this species in Turkey as far as we have found and we cannot therefore be 100% conclusive that it is definitely this species, but the closest match is *Bucherillo litoralis* which has been recorded in nearby location along the Italian coast and in the French Mediterranean Islands [258]. More samples need to be taken and genetic markers must be used for validation. In contrast to all previous invertebrates the species Linyphiidae (Money spider) was only found at one sample site and was only found in the bushes which could be because they seek shelter from the sun, wind or rain. Due to only being found at one sample site it is difficult to define where they are the most commonly located in all five zones. Money spiders are often found in many different habitats, some on ground level and others are found on vegetation and also building, as they are able to travel long distances by producing a small web which allows them to be carried by the wind and move to another place [259]. Formicidae (Ant) were also found at only one individual site. It is suggested that different species usually have different behavior, which can influence diet and other strong variable effect on their resources [260] stating that the different location on sand dunes can contain different species and are habitat niche specific. Therefore, vegetation of the habitat is a very important aspect and also restoration of the flora does not always result in restoration of the fauna [261].

Results from 'One-Way Analysis Bray Curtis Similarity' suggest that the species a) *Phaleria acuminate* were found only in the wet sand zone (Average Abundance 1.33 and Average Similarity 29.56). On the graph it is presented that species b) Tenebrionid (Dunes beetle) were particularly found in the dry sand zone (Average Abundance 17.17 and Average Similarity 64.87). However, species b) were also found in the *Pancratium maritimum* zone (Average Abundance 3.17 and Average

Similarity 8.42) and the Salsola kali zone (Average Abundance 1.67 and Average Similarity 5.73). In the case of species c) *Erodius siculus* it was mostly distributed in dry sand, Pancratium maritimum and Salsola kali zones. In contrast to the other species, there was insufficient data to determine their distribution across the five zones in the sand dunes. In conclusion, it is important to clarify and record the invertebrate assemblages found in the sand dunes during different times of the year and the functions of the sand dune ecosystems, as they could be an important process which support essential human resources. In addition further studies are needed to establish the effects sand dunes have on the ecosystem and how they can help to benefit people's livelihood. It is vitally important to gain understanding ofthe consequences we may face when those unique habitats disappear.

4.2 Nesting Activities of Sea Turtles

4.2.1 Nesting Activities Monitored by Daily Patrols

In this study, the results of monitoring studies at METU-IMS were compared with the two closest official nesting sites in Turkey namely for discussion. The Goksu Delta beach located to the west of METU-IMS beach is considered as a Loggerhead nesting beach [121] of either primary or secondary importance [147] differing according to the views of scientists. The eastern neighbour Alata Beach is not only an important nesting beach for Green turtles but is also used by Loggerheads as a nesting place. All three regions are equally protected from human impact and disturbance. Available published studies covering 2004 and 2008 nesting seasons for Goksu [190] while 2002-2009 nesting seasons for Alata [262] indicated that the 2005 nesting season was [262] considered as a good season for Mediterranean green turtles [263]. To minimize the impact of interannual changes (fluctuations in number) the comparable results were taken as an average of the subsequent years ' data.

4.2.1.1 Emergences and Nest Densities

It is stated that the average annual number of Loggerhead nests throughout the Mediterranean reaches 5031 nests per season, and of these, 1366 nests per season (27.2%) occur on the coasts of Turkey [121] signifying that the nests at IMS-METU represent 0.52% of the total Loggerhead nesting in the Mediterranean and 1.90% of the nesting in Turkey. From another aspect, these nesting estimates for both the Loggerhead and Green turtle indicate that each year 500- 800 Loggerhead turtles nest along the beaches of Turkey [147]. For the Green turtle it is stated that the annual numbers of clutches laid in the Mediterranean vary between 350- 1750 meaning approximately 115-580 females. Furthermore, 99% of all recorded Green turtle nesting occurs in Cyprus and Turkey [264]. Rates of Loggerhead and Green turtle non-nesting emergences and nesting emergences are compared with the results of the nearest western nesting site at Goksu and the nearest eastern nesting site at Alata, given in Table 4.2-1. In terms of Loggerheads, METU-IMS had the lowest non-nesting emergence rate amongst the three regions indicating that the highest emergence rates resulting in nesting were seen at METU-IMS. As the closest nesting site used by both species for nesting, Alata beach obtained higher non-nesting emergence results for Green turtles than METU-IMS again showing that emergences resulting in nesting were also highest for METU-IMS. In summary, METU-IMS yielded lower non-nesting / nesting emergence rates for both species meaning higher rates of emergences which resulted in nesting.

Table 4.2-1 Comparison of non-nesting / nesting emergence rates with the two nearest official nesting sites

Species	**Göksu** [190]	**METU- IMS**	**Alata** [197]**,** [262]
Caretta caretta	2.77	1.54	4.22
Chelonia mydas	-	2.08	3.87

The study site is an important nesting place for both species. A total of 37 turtle nests were identified: 25 *Caretta caretta sp.* and 12 *Chelonia mydas sp.* shown in Figure 3.2-5. Four of the Loggerhead nests were translocated: 2 from KOCA, 1 from outside the region further east of the KOCA zone and the final one from LIM to METU zone. The number of nests per km of entire beach, defined as nest density, is 10.00 N/ km for *Caretta caretta*, 4.62 for *Chelonia mydas* and 14.62 N/km when both species were considered together as summarized in Table 4.2-1 and Table 4.2-2. Among the three nesting sites at Goksu, METU-IMS and Alata, METU-IMS exhibited the highest Loggerhead nest density with a lower Green turtle nest density than Alata.

More detailed interpretation of this data will be given in the following chapters on the spatial and temporal distributions for each species and for both species as a total. In comparison with all nesting beaches of Turkey given in Table 1.1-1 [107]. It is clearly observed that Loggerhead turtles prefer mainly the western region of Turkey with a decrease in numbers towards the east whilst the reverse situation is apparent for Green turtles whose numbers increase towards the east. Based on the average values obtained from this table divided by length of the beach the densities are compared with ours.

Table 4.2-2 Comparison of nest densities with closest nesting sites

Species	**Göksu by distance 35 km** [190]	**METU- IMS by distance 2.60 km**	**Alata by distance 3 km** [197]
Caretta caretta	3.4	10.00	8.67
Chelonia mydas	-	4.62	6.67

Also this table was prepared as a review of available data to decrease the impact of fluctuations in emergence numbers due to regional and species specific changes [216]. It is reported that there is a biennial pattern in Green turtle emergences, namely a low level year followed by a high level year [265]. When our study site is compared with the other nesting sites in Mersin for Loggerheads, Anamur shows a higher nesting and non-nesting density, whereas Goksu, Alata and Kazanli display lower densities. When compared with sites further east, METU-IMS is higher than all. This case changes for *Chelonia mydas* that increase in occurrence from west to east in Turkey. There is no region having a higher density than for the western part of METU-IMS. For the eastern region of Turkey, METU-IMS has higher values than Tuzla, Karatas, Agyatan, Yelkoma and Yumurtalik.

4.2.1.2 Spatial Distribution of emergences and nests

It is clearly understood from Figure 3.2-84.2-6 and Figure 3.2-94.2-7 for both species that fake crawls and nesting crawls were concentrated in the zone at IMS-METU which includes sand dunes and is protected against human disturbance due to the conscientious behaviour of its inhabitants. For both Green turtles and Loggerheads, LIM1 produced a higher emergence ratio and nest density than LIM2. The METU zone is a virgin section of shoreline far from the impact of human activity which is in agreement with the available information that the nesting success of Green turtles is positively correlated with a decline in human activities [185]. LIM1 zone mainly differs from METU due to sand size characteristics. LIM2 as the closest zone to the Lamas river mouth and corresponding human activities was the least successful zone in the 2013 nesting season. METU-IMS: This condensed sub region comprises the highest vegetation among the regions, is covered by sand dunes and shows a spatially reciprocal nesting trend with Loggerheads as nesting crawls were mainly found at the end of the zone in the 2013 nesting season. For the KOCA zone the number of emergences for both species is given in Loggerheads again displayed a higher nest density and nesting success than green turtles. Based on both nesting success and nest density rates, the green turtle values were lower than those of loggerheads as for LIM2, LIM1, and METU zone with an exception of lower loggerhead nesting success in LIM1 due to the high false crawl number as compared with green turtle emergences in this zone. Table 3.2-6 shown in Figure 3.2-12 for Loggerheads and in Figure 3.2-13 for Green turtles. Loggerheads again display higher nest densities and nesting success than Green turtles. Based on both nesting success and nest density, the values for green turtles were lower than for loggerheads as for LIM2, LIM1, and METU zone with an exception of lower loggerhead nesting success in LIM1 due to the high false crawl number compared with green turtle emergences in this zone.

4.2.1.3 Temporal Distribution of Emergences

The timing of the female emergence and searching for a nest placement has been correlated to the tidal cycle, usually occurring at high tide [249]. Moreover, the shorter distances between the nest and the high tide line generates less disorientationof new hatchlings [266]. Emergence from the nests reached its peak for both species in June; producing the results that temporal distribution of nesting for both species focused in May and June as in the other beaches of Turkey and Northern Cyprus [190]. Results are in parall with Goksu Delta where the peak period of Loggerhead nesting is in June [190]. This pattern changes for Alata Beach. For Loggerheads the main nesting was observed in June but the highest number of emergences were recorded in July. For Green turtles both maximum emergences and nesting were observed in July [197]. However, the main nesting season ccurs in July and August in the nesting beaches of Greece (64.5% of the total nests were completed in July and August at Laganas Bay and Kyparissia Bay, Greece) [121] [109]. The reason for this difference in pattern could be caused by geographical variation of the nesting beaches [121].

4.2.1.4 Nesting Success

Nesting success means the number of successful nesting attempts, and indicates effective usage of habitat by sea turtles with regard to no human disturbance and suitable sand properties [267]. For this study, both higher nesting success percentage and higher nest density ratios than nesting attempt ratio (nest density ratio: 2.16, nesting attempt ratio: 1.78) indicate that Loggerheads were more successful in fulfilling the emergence with a nest. One reason could be that the characteristics of the beach meet the requirements of the Loggerheads' more efficiently [64]. In the results section it is indicated that KOCA sub region displays highest nesting success values, although METU sub region has the highest nest density value. From personal observation, the camping site at KOCA sub region may direct turtles to the METU beach. The female turtles searching for a proper nesting site, are disturbed by the crowded, noisy atmosphere and sound vibrations and appear to make no attempt to come ashore along the KOCA zone, although we observed the turtle's presence close to the shoreline in the water. When they are disturbed by mainly humans they prefer the nearest available site at METU. When Loggerhead nesting success results are compared to the results from other parts of Turkey, our results were higher than those reported from northern Karpaz or Lebanon as well as from Goksu, Alata, Patara and Dalyan in Turkey [172] [148] [116] [190], but lower than values from Florida, and Samandag in Turkey [268] [185]. Comparison with the two closest nesting sites is summarized in Table 4.2-3.

Table 4.2-3 Comparison of nesting success of IMS-METU with closest nesting sites

Species	**Göksu** [190]	**METU- IMS**	**Alata** [197]
Caretta caretta	26.5	39.39	35.55
Chelonia mydas	-	32.43	23.95

For Green turtles fluctuations in nesting success were apparent [185]. However, as it was the first time that monitoring of the METU-IMS beach was scientifically evaluated, we had only one year of data to analyse. However, our results were higher than Alata, and lower than Samandag, Kazanli and Akyatan [197] [185] [190] [269]. The high survival nest percentage of 97.37% for METU-IMS emphasizes the importance of the monitoring studies and the positive benefits of the ongoing conservation attempts at IMS-METU.

4.2.1.5 The width of wet, semi-wet, dry regions

For this study, supposing 15 meters from the sea water was chosen as a determining line, only 16% of Green turtle nests were within the line whereas 62% of Loggerhead nests occurred within this zone. From Table 4.2-4 it can be seen that for all regions Green turtle nests were positioned at distances further to the sea than Loggerheads. Similarly, the average distances to the vegetation for Green turtles is shorter than for Loggerheads. These observations were tested statistically. Both variables were normally distributed for each species, there was a significant difference between distance preferences of Loggerheads and Green turtles supporting the hypothesis that Green turtles prefer longer distances to the sea water and closer distances to the vegetation. So statistics support our observations suggesting that different nest site selection preferences based on species could also affect the hatching success and nesting success.

Table 4.2-4 Comparison of the average distances to sea water and vegetation of IMS-METU with closest nesting sites (Alata [197], Göksu [192])

Species	Zones	Distance measurements	
		Avr.Dist.to Sea±S.Dev	Avr.Dst. To Vegetation±S.Dev
Caretta caretta	METU-IMS	14.71 ± 5.52	14.00 ± 14.89
	ALATA	13,42 ± 4.27	NO DATA
	GÖKSU	10.18 ± 3.10	NO DATA
Chelonia mydas	METU-IMS	20.79 ± 11.55	6.23 ± 12.93
	ALATA	14.67 ± 3.23	NO DATA
	GÖKSU	NO DATA	NO DATA

When the distances of the nests to the sea water were compared with Alata and Goksu, METU-IMS and Alata were similar with longer distances than at Goksu for Loggerheads. For Green turtles, thenest distances to the sea water were further for METU-IMS than at Alata.

4.2.1.6 Calculation of Nesting Females

It is hard to comment on one year of data due to the inter-annual changes in sea turtle nesting seasons In this section only the literature search is used to compare closest nesting sites in Table 4.2-5 but it should be noted that the distances of each region were different so comparison could reflect more accurate results when they were handled as density

Table 4.2-5 Comparison of nesting female numbers with closest nesting regions.

	Species	Assumption 1 [216]	Assumption 2 [241]
METU-IMS	*Caretta caretta*	*26/ 3 = 9*	*26/ 2 = 13*
	Chelonia mydas	*12/ 3 = 4*	*12/ 3 = 4*
ALATA [262]	**Species**	**Assumption 1** [216]	**Assumption 2** [241]
	Caretta caretta	*28/ 3 = 9.3*	*28/ 2 = 14*
	Chelonia mydas	*91/ 3 = 30.3*	*91/ 3 = 30.3*
GÖKSU [190]	**Species**	**Assumption 1** [216]	**Assumption 2** [241]
	Caretta caretta	*40*	*60*
	Chelonia mydas	-	-

4.2.1.7 Morphometric Measurements and Avarege Clutch Size

Size resulted from a function of growth rate that changes with temperature [270] [271] also with the quality [272] and quantity [273] of food provided. So, linear regressions and correlation coefficients of the ages and curved carapace lengths of immature turtles show a good fit with data. This case changes for the mature turtles due to the fact that, the very high ages of turtles suppresses the correlation coefficients, but not below that of the immature turtles. These remarks could be summarized as follows; prediction of hatchling size is improved by using the power equations with age as adependent variable, while prediction of adult size is improved by using the linear equations with age as a dependent variable [274]. As all datasets consisted of nesting adult females, statistics were applied by using the Curved Carapace Length parameter amongst others to test the relationships of size with depth, diameter, clutch size, hatching success and distance to the sea water. According to the normality test for each parameter it is seen that size, depth, diameter, clutch size and humidity parameters distributed normally due to p values further tested with parametric tests while the others tested by nonparametric tests. Our results indicate a significant, positive relationship between clutch size and body size which are in agreement with other studies reported by Erharth and Hirth [275] [69]. Furthermore, it is reported that, variation in carapace length accounted for 30% of the variation in clutch size in Loggerheads [276], however, the carapace length accounted for only 16% of the variation in clutch size of Green turtles [268]. Although the clear significant positive relationship between female body size and clutch size is obvious, it is difficult to be confident regarding the estimation of variation in clutch size [277]. Previous studies on annual variation in clutch size report that there is a significant annual variation in clutch size in Loggerheads [276], but no annual variation in clutch size in Green turtles [277]. For METU-IMS long term data is needed to make such an observation. Besides, it is stated [278] that there is a correlation between clutch size and latitude [247] and therefore it is emphasized that variation in clutch sizes among nesting colonies of Loggerheads in Greece, Cyprus and Turkey could be due to body size differences between them. Straight carapace length and straight carapace width explained the greatest amount of variation in clutch size [278]. It is also critical that, larger loggerhead females invest more energy into reproductive output [278] which is understood not from inter-seasonal differences season, but from decreasing clutch sizes later in the season [276]. Mean clutch sizes elsewhere in the Mediterranean have been reported as 74.7 eggs in northern Cyprus [147], 68.5 at Goksu Delta [189], 83.4 at Fethiye [153], 82.0 in Israel [117], 72.7 in Lebanon [111], and 117.7 eggs in Greece [246]. Outwith the Mediterranean, mean clutch sizes vary from between 101 to 126 eggs for the Loggerhead turtles [69].

4.2.1.8 Incubation Duration and Temporal Distribution of Hatching Time

For METU-IMS beach in the 2013 nesting season, (excluding outlier values which are explained in the results section) the average incubation duration was 54. 96 days for Loggerheads and 56. 36 days for Green turtles. The general range of incubation periods for sea turtle nests around the world is quoted as 50-70 days [69]. The incubation durations at various nesting beaches of the Mediterranean were reported as 51.8 days at northern Karpaz [148], 52.0 days at Goksu Delta [190], 53.7 days at

Fethiye [154], 54.0 days in Israel [117], and 55.5 days in Greece [109]. While our results for loggerheads showed a similarity with Goksu, they were higher than for Alata. For green turtles the only comparable region was Alata which had lower values as seen in. Table 4.2-6.

Table 4.2-6 Comparison of incubation duration of IMS-METU with closest nesting sites

Species	**Göksu** [190]	**METU- IMS**	**Alata** [197]
Caretta caretta	53	54. 96	49.44
Chelonia mydas	-	56. 36	51.77

The mean incubation period for METU-IMS in the 2013 breeding season was the highest among the Mediterranean populations. From these values, according to derived field pivotal incubation duration [191] the sex ratios at METU-IMS for both species were biased toward females.The relationship between incubation duration with nest depth was tested (p> 0.05.) and statistical t test for equality of means showed that there was a positive correlation between depth and incubation duration. Another parameter tested with incubation duration was distance to the sea water giving the result of normally distributed data for each species and slight correlation. The most critical parameters that impact egg development at the incubation stage namely temperature and humidity were tested with one another. Normally distributed humidity was tested with Spearman’s rho test producing the result that, there is a significant positive correlation between them. Finally, to test the relationship between distances from the sea with incubation duration, the nesting beach was divided into three zones as:

0.00-10.00

10.01-20.00

$20.00\text{-}\ 20.00^{+}$.

The ranks and results of the test statistics are given in Table 4.2-7.

Table 4.2-7 Correlation of incubatin with distance from the sea

	Distance	N	Mean Rank		
Incubation	0-10m	3	14,67	Chi-Square	7,713
	10-20m	26	22,13	df	2
	20+	8	10,44	Asymp. Sig.	,021
	Total	37			

4.2.1.9 Hatching Success

For loggerheads 77.10 % hatching success results were higher than that of loggerhead turtles on Kizilot, Belek (1990-1996), Patara (1990-1996), Dalyan (1988-1996) and

Samandag [163] [185]. On the other hand, for green turtles 84.98 % hatching success results was higher than Samandag, similar to Kazanli [185] [269]. It is known that hatching success changes not only with the nesting beach but also with nesting seasons [247]. The increase in number of nests laid, eggs produced, and hatchlings released [64] are significant signs of enhanced survival and increased reproductive potential within the population. Sand particle size can also play a major role in hatching success. Sand, which is too fine or too coarse, could cause a decline in hatching success [219]. Hatching success is maximized in sand with particles measuring 0.25 mm to 0.125 mm [279] Hatching success decreases when gas exchange is inhibited by sand particles measuring outside this range [280]. Hatching success is further minimized by other abiotic factors, such as erosion, tidal inundation, nest flooding, heavy rains, thermal stress, and nest density [281]. Many biotic factors lower hatching success including; predation of eggs, parasites and diseases, and egg loss via root invasion of the nest [281]. Unless biotic factors like predation or abiotic factors intervene, emergence success could be greater than 80% [217]. Among the 38 nests recorded on METU-IMS Beach during the 2013 reproductive season, there was no nest exposed to total predation, and there was only one nest where some eggs were predated by foxes (*Vulpes vulpes*). A total of 35 nests were completely protected and no eggs were predated from these nests. Furthermore, 3 loggerhead nests were built close to the high-tide line, but could not be transplanted. Of those, only one failed to produce any hatchlings and the other two displayed successful hatchrates giving a high survivor nest percentage of 97.37% for METU-IMS which again emphasizes the importance of the monitoring studies and the power of the conservation attempts.

4.2.1.10 Nest Parameters

For the maximum hatching success nest site factors have been considered as appropriate distance to the high water mark, nest depth, humidity [244], temperature, sand type and compactness [219]. Flexible-shelled eggs of marine turtles exchange water with surrounding substrate and atmosphere making them dependent upon the interaction of many factors like; humidity, salinity, temperature, gas flow, rainfall, tidal inundation, erosion and predation [282] [283].

- **Depth**

The correlation of nest depth with incubation period was discussed under the heading of incubation duration. Due to larger morphometric measurements, green turtles had deeper nest chambers. Depth was found to be positively associated with incubation.

- **Diameter**

Although there was a significantly positive correlation between size of turtle and depth, there was no significant correlation found between diameter and depth of the nest chamber. The humidity parameter was investigated further to link its impact on nesting, nest and hatching success.

- **Humidity**

As it could be seen from Table 3.2-17, the ranges were extremely wide due to changing physical conditions of nest depth mostly due to the distance from sea water and sand size. To test how moisture correlates with distance nests were grouped according to their distance to the sea water as; 0.00 -10.00 m, 10.01-20.00 m, 20.01-20.00+ .For each group the relation of moisture content was tested with incubation duration and hatching success. According to the distance of groups from sea water, moisture was found to be negatively correlated with distance from the sea ($P<0.05$, r: -0.558). Humidity parameter was also tested with depth, incubation and hatching success as total. There was no significant correlation between humidity and incubation. But hatching success and depth were weakly associated with humidity, implying that when depth increased, so did humidity, and with the increase of humidity, hatching success rose. Based on the information that the eggs are dependent on uptake of moisture from the environment for successful development

[283], it could be said that, humidity is a potential cue but not a reliable factor for nest site selection since it can vary substantially and rapidly in response to rainfall and changes in water regime [218]. Moisture content of LIM1-LIM2 sub regions and METU-KOCA sub regions differ from each other mainly due to the Lamas River which is close to the LIM1-LIM2 sub regions. Similarly, grain size of these 2 groups of sub regions were considerably different affecting nesting success and hatching success. All results showed that METU-KOCA sub regions supplied suitable conditions more efficiently than LIM1-LIM2 sub regions. Furthermore, it is suggested that moisture may affect hatchling size and hatchling performance in oviparous reptiles [219], followed by another study which reported that incubation time was influenced significantly by moisture percentage of substrate [284].

- **Temperature**

The above discussion considers each environmental factor separately but all may be effective as a multiple indicator for hatching success. All the factors combined, namely distance from sea, temperature, distance from vegetation, nest depth, incubation period and moisture may be important for hatching. Temperature is an important factor that affects sex determination, embryo development and hatchling emergence [64]. Another fact is that hatchlings do not start digging towards the surface until the temperature is suitable for their emergence, so when they detect the lower external temperatures which they require (during night time when extreme heat and predation rates are reduced) they can start excavating. However, when hatchlings detect that the exterior temperature is higher than inside the chamber, emergence is cancelled [54].

4.2.2 Nesting Activities Monitored by Camera-Laser Beam System

There are also different studies that used camera records with different aims for sea turtle studies. Some of the recent studies are summarized here, with their purposes for selecting camera usage. A study held at the barrier island in Brevard, Florida used color night vision recorders. One of their main three aims was to obtain images as if in daylight by using only ambient moonlight for illumination. Secondly, they aimed to study behavioral mechanisms underlying the causes of nesting female false crawls. The last but not the least aim was discovering the rare behavior of distressed turtles laying their eggs in the surf [285]. Another study to be mentioned here focussed on the comparison of new technologies to achieve increased resolution and therefore clearer night vision. The advantages and disadvantages of infrared cameras that detect heat radiation emitted by all warm objects, night-vision viewers that emit infrared radiation following usage of the reflected radiation to generate an image, and night-shot video cameras that also emit infrared radiation prior to record the images generated by the reflected radiation were discussed [286]. From another angle, to capture the event of predation on post-emergence sea turtle hatchlings, infrared camera traps were used due to causing fewer disturbances to the predatory animals, the higher chance of capturing natural behavior and the reduced level of man-power with a lowered potential of human-biased results [287]. Similarly, a study from Wisconsin River, Iowa County demonstrated that the use of electric fencing could decrease turtle nest predation by digital trail camera monitoring [288].

The usage of these new monitoring techniques (never experienced anywhere until now), have shown that accurate positioning of the cameras and extensive use of the laser beam systems could greatly increase the efficiency of the monitoring activities during a breeding season, consequently with a greater accuracy of data collected. Although the application of night vision cameras on different nesting beaches has received the interest of researchers increasingly, this is the first study whereby these systems were adopted aiming at simultaneous identification of nesting females on the beach by twofold alarm systems, simultaneous determination of exact geological information, simultaneous identification of the hatching period beginning with movements at surface of the nest chamber, observation of behavioral ecology of both nesting females and hatchlings and lastly monitoring any type of predation attempts possible to ocur during the whole season and covering the entire study area. To summarize the conclusions about an automated camera-laser beam system; IR camera- laser barrier coupled system could be a promising tool for sea turtle nest monitoring substituting labor-intensive surveys. Following studies could include the upgrading of such a system with enhanced image processing technologies. From a wider scope, the visual fingerprinting and monitoring of wild populations which rely on a database of images and records could support additional insight to patrolling within standardized intervals that decrease the precision of data collection on nesting females on the beach and to synthetic markers providing autonomous, nonintrusive population monitoring. This idea of visual fingerprinting aims at minimizing disturbance with robust population monitoring. The application which needs a computer vision system that automatically identifies unique biometric features was applied for African penguins *Spheniscus demersus* at Robben Island, South Africa and gave 96.7% accuracy with high precision identification of known individuals [289]. This was the first study using whole systems to detect nesting females in the field without regular night patrols with the motivation of minimizing human disturbance to the turtles. As a result of goals achieved by adopting these systems, we as researchers gained invaluable time for analyses and the risk of human disturbance (even the vibrations that occurr while walking during night patrolling) were minimized. The Laser beam system has proved a very useful tool which systematically revealed the presence of sea turtles on the beach. It is therefore a valuable tool with which researchers can save both time and effort in the patrols, but above all allows an increase in data cataloging such as carapace measurements and the exact location of a nest, because once the turtle has crossed the laser beams, researchers immediately know where to go defined by the night vision cameras.

4.3 Stranding Activities

The annual estimations on the numbers of marine turtles which have been incidentally captured or entangled in fishing nets in the Mediterranean Sea amounts to thousands of turtles each year. One of the main reasons for anthropogenic mortality is longline fisheries bycatch however studies are not efficient enough due to data limitations and spatial coverage of bycatch information [290]. Unfortunately, despite increasing studies, there is little information on the oceanic and neritic habitats of marine turtles in Turkey. Stranding data is important to draw attention to the winter habitats of juveniles as well as foraging grounds. Early reports [106] indicate that immature green turtles stay more or less around their birthplace, while loggerhead turtles migrate further distances. Our observations support that information with a higher percentage of immature green turtles stranding (50% of loggerheads were juvenile whereas 66.67% of green turtles were small juveniles, and 33.33% were juvenile) than loggerhead juveniles. This data is in agreement with a 14 year loggerhead stranding turtle study from the Valencian Community in eastern Spain demonstrating stranding occurred mainly in juveniles and was far more frequent in the summer months [290]. Two stranding reports from this study are detailed below to draw attention to the extreme difficulties that the sea turtles face. Studies have shown that drifting longlines and bottom trawls have the greatest impact on the Mediterranean turtle populations, in pelagic and demersal phases respectively, while passive nets (gillnets and trammel nets) seem to be responsible for the highest direct mortality, due to drowning [291]. Other devastating results showed that ingested branch lines are one of the major causes of sea turtle mortality. Although squid bait is expected to catch mackerel in fact it catches more turtles. In the same way, light sticks attract turtles strongly. Usage of circle hooks could reduce the potential of turtle mortality in certain fisheries and areas. Additionally, bigger hooks are less likely to be swallowed by turtles due to physical constraints of the mouth, reducing the mortality rate and the catch of juveniles [292]

4.4 Genetic Barcoding

A perfect match 100% similarity were found with respect to the cox1 barcodes between Turkey and Greece *Caretta caretta* samples also, 99% similarity were observed between all others. According to Kimura 2-Parameter model, distance between Turkey and Greece *Caretta caretta* samples is 0,000; Turkey and Gene bank mined sample (CYTC5514-12) 0,002 and 0,008 value was observed between all others. It is clearly seen that the Turkey samples have been located between U.S. and Australia samples. This is the first time the Turkey coast samples has been barcoded.

4.5 Future Work Aimed at Tracking Studies on Sea Turtles

Data from the tracking system was automatically uploaded to the user web site domain. From this address data log of the system can be seen on google maps. Information such as total distance, average speed, etc. are displayed below the map. Tracking system, can take measurements periodically with the user defined time intervals. Higher time intervals are better for longer battery life. On the other hand, shorter time intervals produce better mapping of the turtle tracks.

Figure 4.5-1 Sample map obtained from calibration and depth durability tests

REFERENCES

[1] Hirayama, R., "Oldest known sea turtle," *Nature*, vol. 392, pp. 705-708, 1998.

[2] Naro- Maciel,E., Le, M., FitzSimmons, N., Amato, G., "Evolutionary relationships of marine turtles: A molecular phylogeny based on nuclear and mitochondrial genes," *Molecular Phylogenetics and Evolution,* vol. 49, pp. 659-662, 2008.

[3] Pritchard, P.C.H., "Evolution, phylogeny, and current status," in *The Biology of Sea Turtles*, New York, CRC Press, 1996, pp. 1-28.

[4] Dutton, P.H., "Use of molecular markers for stock identification, fingerprinting, and the study of mating behavior in leatherback turtles," in *Proceedings of the International Symposium on Sea Turtle Conservation*, NOAA Technical Memorandum NMFS-SEFSC, 1996.

[5] Karl, S.A., Bowen, B.W., "Evolutionary significant units versus geopolitical taxonomy:molecular systematics of an endangered sea turtle (genus Chelonia)," *Conservation Bioligy,* vol. 13, pp. 990-999, 1999.

[6] Chassin-Noria, O., Abreu-Grobois, A., Dutton, P. H. and Oyama, K., "Conservation genetics of the east Pacific green turtle (Chelonia mydas) in Michoacan, Mexico," *Genetica,* vol. 121, pp. 195-206, 2004.

[7] Gaffney, E.S., "A phylogeny and classification of the higher categories of turtles," *Bulletin of the American Museum of Natural History,* vol. 155, pp. 387-436, 1975.

[8] Gaffney, E.S., Meylan, P.A., "A phylogeny of turtles," in *The Phylogeny and Classification of Tetrapods*, Oxford, Clarendon Press, 1988, pp. 157-219.

[9] Meylan, A.B., Meylan, P.A., "Introduction to the Evolution, Life History, and Biology of Sea Turtles," in *Research and Management Techniques for the Conservation of Sea turtles*, Pennsylvania, USA, IUCN/SSC Marine Turtle Specialist Group Publication, 1999.

[10 Wyeneken, J., "The External Morphology, Musculoskeletal System, and Neuro-

] Anatomy of Sea Turtles," in *The Biology of Sea Turtles*, Florida, CRC Press, 2003, pp. 39-79.

[11] Wyneken, J., "Sea turtle locomotion: mechanics, behavior, and energetics," in *The Biology of Sea Turtles*, FL, CRC Press, 1997, pp. 165-198.

[12] Cott, H.B., Adaptive Coloration in Animals, London: Methuen, 1966.

[13] Owen, D.F., Camouflage and Mimicry, University of Chicago Press: Chicago, 1982.

[14] Pritchard, Peter C. H.; Mortimer, A. Jeanne, Research and Management Techniques for the Conservation of the Sea Turtles, IUCN/SSC Marine Turtle Specialist Group Publication, 1999.

[15] Pritchard, P.C.H., Encyclopedia of Turtles, NJ: Neptune, 1979.

[16] Wyneken, J., "The Anatomy of Sea Turtles," in *NOAA Technical Memorandum*, Miami, 2001.

[17] Ruckdeschel, C., Shoop, C.R., Zug, G.R., Sea Turtles of the Georgia Coast, St. Marys, GA: Cumberland Island Museum, 2000.

[18] Schumacher, G.H., "Head muscles and hyolaryngeal skeleton of turtles and crocodilians," in *Biology of the Reptilia*, New York, Academic Press, 1973, pp. 101-199.

[19] Youngkin, D., "A long-term dietary analysis of loggerhead sea turtles (Caretta caretta) based on strandings from Cumberland Island, Georgia Master's thesis," Florida Atlantic University, FL, 2001.

[20] Henson, T., Boettcher, R. Godfrey, M., Cluse, W., Handbook for Sea Turtle Volunteers in North Carolina, North Carolina: North Carolina Wildfire Resources Commision, 2006.

[21] Hyman, L.H., Wake, M.H., Hyman's Comparative Vertebrate Anatomy, Chicago: University of Chicago Press, 1979.

[22] Liebman, P.A., "Photochemistry of Vision:Microspectrophotometry of phototreceptors," *Handbook of Sensory Physiology*, vol. 2/1, p. 481, 1972.

[23] Ehrenfeld, D.W., Carr A., "The role of vision in the sea-finding orientation of the greenturtle (Chelonia mydas)," *Animal Behavior,* vol. 15, p. 25, 1967.

[24] Ehrenfeld, D.W., Koch, A.L., "Visual accommodation in the green turtle," *Science,* vol. 155, p. 827, 1967.

[25] Granda, A.M., O'Shea, P.J., "Spectral sensitivity of the green turtle (Chelonia mydas) determined by electrical responses to heterochromatic light," *Brain Behavior Evolution,* vol. 5, p. 143, 1972.

[26] Granda, A.M., "Eyes and their sensitivity to light of differing wavelengths, in Turtles," in *Perspectives and Research*, New York, John Wiley & Sons, 1979, p. 247.

[27] Bartol, S.M., Musick, J.A., Ochs, A.L., "Visual acuity thresholds of juvenile loggerhead sea turtles (Caretta caretta):an electrophysiological approach," *Comp. Physiology,* vol. 187, p. 953, 2002.

[28] Oliver, L.J., "Retinal anatomy of hatchling sea turtles: anatomical specializations and and behavioral correlates," *Marine Freshwater Behavioral Physiology,* vol. 33, p. 233, 2000.

[29] Bartol, S.M., Musick, J.A., "Morphology and topographical organization of the retina of juvenile loggerhead sea turtles (Caretta caretta)," *Copeia,* vol. 3, p. 718, 2001.

[30] Bartol S.M.., Musick,, J.A., "Sensory Biology of Sea Turtles," in *The Biology of Sea Turtles,* New York, CRC Press, 1996, pp. 80-102.

[31] Lenhardt, M.L., Klinger, R.C., Musick, J.A., "Marine turtle middle-ear anatomy," *Aud. Research,* vol. 25, p. 66, 1985.

[32] Wever, E.G., The Reptile Ear: Its Structure and Function, Princeton, NJ: Princeton University Press, 1978.

[33] Turner, R.G., "Physiology and bioacoustics in reptiles," in *Comparative Studies of Hearing in Vertebrates*, New York, Springer-Verlag, 1978, p. 205.

[34] Parsons, T.S., "Anatomy of nasal structures from a comparative viewpoint," in *Handbook of Sensory Physiology,* Berlin, Springer-Verlag, 1971, p. 1.

[35] Tucker, D., "Nonolfactory responses from the nasal cavity: Jacobson's organ

] and the trigeminal system," in *Handbook of Sensory Physiology*, Berlin, Springer-Verlag, 1971, p. 151.

[36] Scott, T.R., "The chemical senses, in Turtles," in *Perspectives and Research*, New York, John Wiley & Sons, 1979, p. 267.

[37] McCutcheon, F.H., "The respiratory mechanism in turtles," *Physiological Zoology,* vol. 16, p. 255, 1943.

[38] Root, R.W., "Aquatic respiration in the musk turtle," *Physiological Zoology,* vol. 22, p. 172, 1949.

[39] Grassman, M., Owens, D., "Chemosensory imprinting in juvenile green sea turtles,Chelonia mydas," *Animal Behavior,* vol. 35, p. 929, 1987.

[40] Bjorndal, K.A., Bolten, A.B., "From Ghost to Key Species:Restoring Sea Turtle Populations to Fulfill their Ecological Roles," *Marine Turtle Newsletter,* vol. 100, pp. 16-21, 2003.

[41] WWF, "Species Factsheets - Marine Turtles," 2007. [Online]. Available: www.panda.org/about_wwf/what_we_do/species/about_species/species_factsheets/marine_turtles/. [Accessed 28 January 2009].

[42] Bjorndal, K.A., Bolten, A.B., Chaloupka, M.Y., "Green turtle somatic growth model: Evidence for density dependence," *Ecological Applications,* vol. 10, pp. 269-282, 2000.

[43] Goatley, C.H.R., Hoey, A.S., Bellwood, D.R., "The Role of Turtles as Coral Reef Macroherbivores," *PLoS ONE,* vol. 7, no. 6, 2012.

[44] Heithaus, M. R., McLash, J. M., Frid, A., Dill, L. M., Marshall, G. J., "Novel insights into the behavior of sea turtles from animal-borne cameras," *Journal of the Marine Biological Association of the United Kingdom,* vol. 82, pp. 1049-1050, 2002.

[45] Hatase, H., Sato, K., Yamaguchi, M.,Takahashi, K., Tsukamoto, K., "Individual variation in feeding habitat use by adult female green sea turtles (Chelonia mydas): Are they obligate neritic herbivores?," *Oecologia,* vol. 149, pp. 52-64, 2006.

[46 Seminoff, J.A., Jones, T.T., Marshall, G.J., "Underwater behavior of green

] turtles monitored with video-time-depth recorders: What’s missing from dive profiles?," *Marine Ecology Progress Series,* vol. 322, pp. 269-280, 2006.

[47] Burkholder, D. A., Heithaus, , M. R., Thomson, J. A., Fourqurean, J. W., "Diversity in trophic interactions of green sea turtles Chelonia mydas on a relatively pristine coastal foraging ground," *Marine Ecology Progress Series*, vol. 439, pp. 277-293, 2011.

[48] Lemons, G., Lewison, R., Komoroske, L., Gaos, A., Lai, C., Dutton, P., Eguchi, T., LeRoux, R., Seminoff, J. A., "Trophic ecology of green sea turtles in a highly urbanized bay: Insights from stable isotopes and mixing models," *Journal of Experimental Marine Biology and Ecology,* vol. 405, pp. 25-32, 2011.

[49] Zieman, J.C., Fourqurean, J.W., and Frankovich, T.A, "Seagrass die-off in Florida Bay: Long-term trends in abundance and growth of turtle grass,Thalassia tertudinum," *Estuaries,* vol. 22, pp. 460-470, 1999.

[50] Jackson, J.B.C., Kirby, M.X., Berger, W.H., Bjorndal, K.A., Botsford, L.W., Bourque, B.J., Bradbury, R.H., Cooke, R, Erlandson, J., Estes, J.A., "Historical overfishing and the recent collapse of coastal ecosystems," *Science,* vol. 293(5530), p. 29–637, 2001.

[51] Jackson, J.B.C, "Reefs since Columbus," *Coral Reefs,* vol. 16, pp. 23-32, 1997.

[52] Preen, A. R., "Infaunal mining: A novel foraging method of loggerhead turtles," *Journal of Herpetology,* vol. 30, pp. 94-96, 1996.

[53] Thomson, J. A., Heithaus, M. R., Burkholder, D. A., Vaudo, J. J., Wirsing, A. J., Dill, L. M., "Site specialists, diet generalists? Isotopic variation, site fidelity and foraging by loggerhead turtles in Shark Bay, Western Australia," *Marine Ecology Progress Series,* vol. 453, pp. 213-226, 2012.

[54] Musick, J. A., Limpus, C. J., "Habitat utilization and migration in juvenile sea turtles," in *The Biology of Sea Turtles*, Boca Raton, FL, CRC Press, 1997, pp. 137-164.

[55] Bolten, A. B., "Active swimmers—Passive drifters: The oceanic juvenile stage of loggerheads in the Atlantic system," in *Loggerhead Sea Turtles,* Washington,

DC, Smithsonian Books, 2003, p. 63–78.

[56] Frid, A., Dill, L. M., "Human caused disturbance stimuli as a form of predation risk," *Conservation Ecology,* vol. 6, no. 11, 2002.

[57] Frid, A., Heithaus, M.R., "Conservation and anti-predator behavior," in *Encyclopedia of Animal Behavior,* Amsterdam, The Netherlands, Elsevier, 2010, pp. 366-376.

[58] Heithaus, M.R., "Predators, Prey, and the Ecological Roles of Sea Turtles," in *The Biology of Sea Turtles,* London, NY, CRC Press, 2013, pp. 250-273.

[59] Wilson, E.G., Miller,K.L., Allison,D., Magliocca,M., "Why Healthy Oceans Need Sea Turtles: the importance of sea turtles to marine ecosystems," OCEANA, USA, 2012.

[60] Dean, R., "Beach Nourishment: Theory and Practice," *World Scientific,* p. 399, 2002.

[61] Bouchard, S.S., Bjorndal, K.A., "Sea Turtles as Biological Transporters of Nutrients and Energy from Marine to Terrestrial Ecosystems," *Ecology,* vol. 81, no. 8, pp. 2305-2313, 2000.

[62] Dodd, C.K., Jr., "Synopsis of the biological data on the loggerhead sea turtle Caretta caretta (Linnaeus 17589)," U.S. Fish and Wildlife Service, 1988.

[63] Fowler, L.E., "Hatching success and nest predation in the green sea turtle, Chelonia mydas, at Tortuguero, Costa Rica," *Ecology,* vol. 60, pp. 946-955, 1979.

[64] Miller, "Reproduction in sea turtles," in *The Biology of Sea Turtles,* Boca Raton, Florida, USA., CRC Press, 1997, pp. 51-81.

[65] Bowen, B.W., Karl, A., "Population genetics and phylogeography of sea turtles," *Molecular Ecology,* vol. 16, no. 4886-4907, 2007.

[66] Entertainment, Seaworld Parks , "seaworld," Seaworld Parks and Entertainment, 11 MAY 2014. [Online]. Available: http://seaworld.org/animal-info/animal-infobooks/sea-turtles/habitat-and-distribution/. [Accessed 13 July 2014].

[67] Plotkin, P., "Adult Migrations and Habitat Use," in *The Biology of Sea Turtles,* Washington D.C., CRC PRESS, 2003, pp. 225-233.

[68] Hirth, H., Hoolingworth, S., L., "Report to the government of the People's Democratic Republic of Yemen on marrine turtle management," FAO/UNDP, 1973.

[69] Hirth, H.F., "Some aspects of the nesting behavior and reproductive biology of sea turtles," *Am. Zool,* vol. 20, pp. 507-523, 1980.

[70] McClellan, C.M., "Behavior, Ecology, and Conservation of Sea Turtles in the North Atlantic Ocean," Doctor of Philosophy in the Department of Environment in the Graduate School of Duke University, 2009.

[71] Bolten, A.B., "Variation in sea turtle life history patterns: neritic vs. oceanic developmental stages," in *Biology of Sea Turtles, volume II.*, Boca Raton, FL, CRC Press, 2003, pp. 243-257.

[72] Wyeneken, J., Salmon, M., "Frenzy and post frenzy swimming activity in loggerhead, green and leatherback hatchling turtles," *Copea,* pp. 478-484, 1992.

[73] Lohmann, K. J., Lohmann, C. M. F., "Orientation mechanisms of hatchling loggerheads," in *Biology and conservation of the loggerhead sea turtle*, Washington, D.C., USA, Smithsonian Institution Press, 2003.

[74] Bjorndal, K. A.,Bolten, A. B., Koike, B., Schroeder, B. A., Shaver, D.J., Teas, W. G, Witzell, W. N., "Somatic Growth Function for Immature Loggerhead Sea Turtles in Southeastern U.S. Waters," *Fishery Bulletin,* vol. 99, pp. 240-246, 2001.

[75] Kamezaki, N., Matsui, M., "Allometry in the loggerhead turtle, Caretta caretta," *Chelonian Conservation and Biology,* vol. 2, pp. 421-425, 1997.

[76] Laurent, L., P. Casale, M.N. Bradai, B.J. Godley, G. Gerosa, A.C.Broderick, W. Schroth, B. Schierwater, A.M. Levy, D. Freggi,E.M. Abd El-Mawla, D.A. Hadoud, H.E. Gomati, M. Domingo,M. Hadjichristophorou, L. Kornaraky, F. Demirayak and Ch.Gautier, "Molecular resolution of marine turtle stock composition in fishery bycatch: a case study in the Mediterranean," *Molecular Ecology,* vol. 7, pp. 1529-1542, 1998.

[77] Tiwari, M., Bjorndal, K.A., Bolten, A.B., Moumni, M., "Morocco and Western Sahara: sites of an early neritic stage in the life history of loggerheads?," in

Twentieth Annual International Symposium on Sea Turtle Biology and Conservation, Orlando, Florida, 2000.

[78] Carr, A., "Some problems of sea turtle ecology," *American Zoology*, vol. 20, pp. 489-498, 1980.

[79] Hendricson, J.R., "The green sea turtle Chelonia mydas in Malaya and Sarawak," *Proc. Zool. Soc.*, vol. 130, pp. 455-535, 1958.

[80] Bowen, B.W., Bass, A.L., Soares, L., Toonen, R.J., "Conservation implications of complex population structure: lessons from the loggerhead turtle (Carettacaretta)," *Molecular Biology*, vol. 14, pp. 2389-2402, 2005.

[81] Lohmann, K.J., Putman, N.F., Lohmann,C.M.F, "Geomagnetic imprinting: A unifying hypothesis of long distance natal homing in salmon and sea turtles," *PNAS*, vol. 105, 2008.

[82] Miller, J.D., Limpus, C.L., Godfrey, M.H, "Nest site selection, oviposition, eggs, development, hatching, and emegence of loggerhead sea turtles," in *Ecology and Conservation of Loggerhead Sea Turtles*, Gainesville, Florida, University Press of Florida, 2003, pp. 125-143.

[83] Chaloupka, M.Y., Limpus, C.J., "Survival probability estimates for the endangeredloggerhead sea turtle resident in southern Great Barrier Reef waters," *Marine Biology*, vol. 140, pp. 267-277, 2002.

[84] Yntema, C.L., Mrosovsky, N., "Sexual differentiation in hatchling loggerheads (Caretta caretta) incubated at different controlled temperatures," *Herpetologica*, vol. 36, pp. 33-36, 1980.

[85] Morreale, S.J., "Temperature dependent sex determination: current practices threaten conservation of sea turtles," *Science*, vol. 216, pp. 1245-1247, 1982.

[86] Standora, E.A., Spotila, J.R., "Temperature dependent sex determination in sea turtles," *Copea*, vol. 3, pp. 711-722, 1985.

[87] Spotila, J.R., "Temperature dependent sex determination in the green turtle(Chelonia mydas): effects on the sex ratio on a natural nesting beach," *Herpetologica*, vol. 43, pp. 74-81, 1987.

[88 Bowen, B.W. , Karl, S.A., "Population genetics and phylogeography of sea

] turtles," *Molecular Ecology,* vol. 16, no. 23, pp. 4886-4907, 2007.

[89] Lee, P.L.M., "Molecular Ecology of marine turtles:New approaches and future directions," *Journal of Experimental Marine Biology and Ecology,* vol. 356, no. 1-2, pp. 25-42, 2008.

[90] Wallace, B.P., Finkbeiner, E.M., DiMatteo,A.D.,Helmbrect, S., "A framework for global threats evaluation, gap analyses, diversity hotspots assessment, and conservation priority setting for marine turtles," in *First International Marine Conservation Congress, Society of Conservation Biology*, Washington, DC., 2009.

[91] Kritzer, J.P., Sale P.F., Marine Metapopulations, New York: Academic Press, 2006.

[92] Jones, C.M, "Estuarine and diadromous fish metapopulations," in *Marine Metapopulations*, Burlington, Massachusetts, Elsevier Academic Press, 2006.

[93] Avise, J.C., Bowen,B.W., Lamb,T. , Meylan, A.B., Bermingham, E., "Mitochondrial DNA evolution at a turtle’s pace: Evidence for low genetic variability and reduced microevolutionary rate in the Testudines," *Molecular Biology and Evolution,* vol. 9, pp. 457-473, 1992.

[94] Bowen, B.W., Meylan, A.B. , Ross, J.P., Limpus, C.J., Balazs, G.H., Avise, J.C., "Global population structure and natural history of the green turtle (Chelonia mydas) in terms of matriarchal phylogeny," *Evolution,* pp. 865-881, 1992.

[95] Karl, S.A., Bowen, B.W., Avise, J.C., "Global population structure and male-mediated gene flow in the green turtle (Chelonia mydas): RFLP analysis of anonymous nuclear DNA regions," *Genetics,* vol. 131, pp. 163-173, 1992.

[96] Peare, T., Parker, P.G., Irwin, M.E., "Paternity analysis in the green sea turtle.," in *Sixteenth Annual Symposium on Sea Turtle Biology and Conservation,. NOAA Technical Memorandum NMFS-SEFSC-412*, Springfield, Virginia, 1998.

[97] Schroth, W., Streit, B., Schierwater, B., "Evolutionary handicap for turtles," *Nature,* vol. 384, pp. 521-522, 1996.

[98] Vignal, A., Milan, D., SanCristobal,M., Eggen, A., "A review on SNP and other types of molecular markers and their use in animal genetics," *Genetics Selection*

Evolution, vol. 34, no. 3, pp. 275-305, 2002.

[99] Dethmers, K. E.M., Broderick, D.,Moritz, C., "The genetic structure of Australasian green turtles(Chelonia mydas): Exploring the geographical scale of genetic exchange," *Molecular Ecology,* vol. 15, p. 3931–3946, 2006.

[100] Formia, A., Godley, B. J., Dontaine,J. F., Bruford, M.W., "Mitochondrial DNA diversity and phylogeography of endangered green turtle (Chelonia mydas) populations in Africa," *Conservation Genetics,* vol. 7, pp. 353-369, 2006.

[101] Bourjea, J., Lapègue, S., Gagnevin, L. et al., "Phylogeography of the green turtle, Chelonia mydas, in the Southwest Indian Ocean," *Molecular Ecology,* vol. 16, pp. 175-186, 2007.

[102] Encalada, S.E., Bjorndal, K.A., Bolten, A.B., Zurita, C.J., Schroeder, B., Possardt, E., Sears, C.J., Bowen, B.W., "Population structure of loggerhead turtle (Caretta caretta) nesting colonies in the Atlantic and Mediterranean as inferred from mitochondrial DNA control region sequences," *Marine Biology,* vol. 130, pp. 567-575, 1998.

[103] Shamblin, B. M., Dodd, M.G., Bagley, D.A., "Genetic structure of the southeastern United Statesloggerhead turtle nesting aggregation: Evidence of additional structure within the peninsular Florida recovery unit," *Marine Biology,* vol. 158, pp. 571-587, 2011.

[104] Yilmaz, C.,Turkozan,O., Bardakci, F., "Genetic structure of loggerhead turtle (Caretta caretta) populations in Turkey," *Biochem. Syst. Ecol,* vol. 39, pp. 266-276, 2011.

[105] Naro-Maciel E., Reid, B., Fitzsimmons, N., Le, M., Dessale, R., Amato, G., "DNA barcodes for globally threatened marine turtles: a registry approach to documenting biodiversity," *Molecular Ecology Resources,* 2010.

[106] Baran, I. , Kasparek, M., Marine Turtles in Turkey: Status Survey 1988 and Recommendations for Conservation and Management, Heidelberg: World Wide Fund for Nature, 1989.

[107] Türkozan, O., Kaska, Y., "Turkey," in *Sea Turtles in the Mediterranean Distirbution and conservation priorities*, Switzerland, IUCN/SSC Marine Turtle

Specialist Group, 2010, pp. 257-294.

[108] Colasimone, L. , Bennet J. , Cooke, K., *Med Waves*, Greece: UNEP/MAP United Nations Environment Programme/ Mediterranean Action Plan, 2010.

[109] Magaritoulis, D., "An estimation of the overall nesting activity of the loggerhead turtle in Greece," in *18th International Symposium on Sea Turtle Biology and Conservation Mazatlan*, Sinaloa Mexico, 1998.

[110] Geldiay, R. , Koray, T., Balik, S., "Status of the sea turtle population (Caretta caretta and Chelonia mydas) in the northern Mediterranean Sea, Turkey," in *Biology and Conservation of Sea Turtles*, Washington, Smithsonian Institution Press, 1982, pp. 424-435.

[111] Laurent, L. , Bradai, M. N. , Hadoud, D. H. , El Gomatai, H. M. , Hamza, A. A., "Marine Turtle Nesting Activity Assessment on Libyan Coasts, Phase 3: Survey of the Coast to the west of Misratah," in *SPA/RAC and UNEP*, Tunis, 1999.

[112] Yerli S. V. , Canbolat, A. F., Principles of the Management Plan for the Protection of Sea Turtles in the Specially Protected Areas (Koycegiz-Dalyan, Patara, Fethiye-Calis, Belek, Goksu Delta), Ankara: Ministry of Environment, APSA (The Authority for the Protection of Special Areas) Publication (ISBN 975-7347-43-4), 1998.

[113] Yerli, S. V., Canbolat, A. F. , Ulug, H. , Dogan, O., Principles of the Management Plan for the Protection of Sea Turtles in the West Mediterranean Coasts of Turkey., Ankara: Ministry of Environment, GDEP Publication, ISBN 975-7347-45-0, 1998.

[114] Laurent, L. , Bradai. , M. N. , Hadoud, D. H. , El Gomatai H. M., "Phase I: Survey of the Coast Between Egyptian Border and Sirte," in *Marine Turtle Nesting Activity Assessment on Libyan Coasts*, Tunis, 1995.

[115] Broderick, A. C. , Godley, B.J., "Population and nesting ecology of the green turtle, Chelonia mydas, and the loggerhead turtle, Caretta caretta, in Northern Cyprus," *Zoology in the Middle East*, pp. 27-46, 1996.

[116] Demetropoulos, A. , Hadjichristophorou, M., "Sea turtle conservation in Cyprus," *Marine Turtle Newsletter*, pp. 4-6, 1989.

[117] Laurent, L. , Nouira, S. , Jeudy De Grissac, A. , Bradai, M. N., "Les tortues marines de Tunisie: Premières données," *Bulletin de la Société Herpétologique de France,* pp. 1-17, 1990.

[118] Clarke, M. , Campbell, A. C. , Hameid, W. S. , Ghoneim, S., "Preliminary report on the status of marine turtle nesting populations on the Mediterranean coast of Egypt," *Biological Conservation,* pp. 363-371, 2000.

[119] Kasperek, M., "The nesting of marine turtles in the Mediterranean coast of Syria," *Zoology in the Middle East,* pp. 51-62, 1995.

[120] Kuller, Z., "Current status and conservation of marine turtles on the Mediterranean coast of Israel," *Marine Turtle Newsletter,* pp. 3-5, 1999.

[121] Margaritoulis, D., Argano, R., Baran, I., Bentivegna, F., Bradai, M.N., Caminas, J.A., Casale, P., De Metrio, G., Demetropoulis, A., Gerosa G., Godley, B.J., Haddound, D.A., Houghton, J., Laurent, L., Lazar, B., "Loggerhead turtles in the Mediterranean Sea: present knowledge and conservation perspectives," in *Loggerhead Sea Turtles*, Washington, USA, 2003, pp. 175-198.

[122] Yerli, S. V. , Demirayak, F., "Marine Turtles in Turkey: A Survey on Nesting Site Status," DHKD, CMS , Istanbul, 1996.

[123] Yerli, S. V. , Canbolat, A. F., "Principles of the Management Plan for the Protection of Sea Turtles in the East Mediterranean Coasts of Turkey," Ministry of Environment, GDEP Publication, Ankara, 1998.

[124] Hathaway, R. R., "Sea turtles, unanswered questions about sea turtles in Turkey," *Balık ve Balıkçılık,* vol. 20, pp. 1-8, 1972.

[125] Kasperek, M., Godley, B.J., Broderick, A.C., "Nesting of the green turtle, Chelonia mydas, in the Mediterranean: review of thestatus and conservation needs," *Zoology in the Middle East*, vol. 24, pp. 45-74, 2001.

[126] Pearce, A.F, Contrasting Population Structure of the Loggerhead Turtle (Caretta caretta) Using Mitochondrial and Nuclear DNA Markers, Florida: University of Florida, 2001.

[127] Bowen, B., J.C. Avise, J.I. Richardson, A.B. Meylan, D., "Population structure of loggerhead turtles (Caretta caretta) in the north western Atlantic Ocean and

Mediterranean Sea.," *Conservational Biology,* vol. 7, pp. 834-844, 1993.

[128] McCracken G.F., McCracken M.K., Vawter A.T., "Genetic structure in migratory populations of the bat Tadarida brasiliensis mexicana," *Journal of Mammology,* vol. 75, pp. 500-514, 1994.

[129] Hamrick, J.L., Godt, M.J.W., "Effects of life history traits on genetic diversity in plant species," *Philosophical Transactions of the Royal Society of London,* vol. 351, p. 1291–1298, 1996.

[130] Kaska, Y., "Genetic Structure of Mediterranean sea turtle populations," *Turkish Journal of Zoology,* vol. 24, pp. 191-197, 2000.

[131] Lahanas, P.N, Miyamoto, M.M., Bjorndal, K.A., Bolten, A.B., "Molecular evolution and population genetics of Greater Caribbean green turtles (Chelonia mydas) as inferred from mitochondrial DNA control region sequences," *Genetica,* vol. 94, pp. 57-67, 1994.

[132] Encalada, S.E., Lahanas, P.N., Bjorndal, K.A., Bolten, A.B.,Miyamoto, M.M., Bowen B.W., "Phylogeoraphy and population structure of the Atlantic and Mediterranean green turtle Chelonia mydas: a mitochondrial DNA control regions sequence assessment," *Molecular Ecology,* vol. 5, pp. 473-483, 1996.

[133] Bowen, B.W., Kamezaki, N., Limpus, C.L., Hughes, G.H., Meylan,A.B., Avise, J.C.,, "Global phylogeography of the loggerhead turtle (Caretta caretta) as indicated by mitochondrial DNA haplotypes," *Evolution,* vol. 48, pp. 1820-1828, 1994.

[134] Carreras, C., Pascual, M., Cardona, C., Anguilar, A., Margaritoulis, D., Rees, A., Turkozan, O., Levy, Y., Gshid, A., Aureggi, M., Khalil, M., "The genetic structure of the loggerhead sea turtle (Caretta caretta) in the Mediterranean as revealed by nuclear and mitochondrial DNA and its conservation implications," *Conservation Genetics,* vol. 8, pp. 761-775, 2007.

[135] Yılmaz, C., Turkozan, O.,Bardakci, F., "Population Genetic structure of loggerhead turtle (Caretta caretta) populations in Turkey based on mt DNA SEQUENCES," in *Third Mediterranean Conference on Marine Turtles,* Tunisia, 2008.

[136] Baran, İ., Kasperek M., "Marine TurtlesTurkey. Status Survey 1988 and recommendadtions for conservationand management," Heidelberg, Germany, 1999.

[137] Basoglu, M., "Türkiye Amphibileri," Ege Universitesi, Fen Fakultesi Kitaplar Ser. 50, Izmir, Turkey, 1973.

[138] Basoglu, M. Baran, İ., "Anadolu sahillerinde toplanan deniz kaplumbağası materyali üzerine kısa bir rapor," *Doğa, Temel Bilimler,* vol. 6, no. 2, pp. 69-71, 1982.

[139] Geldiay, R. Koray, T., "Reasearch on the conservtion of marine turtle populations (Caretta caretta and Chelonia mydas) annd precautions at the Aegean and Mediterranean coasts of Turkey," TUBITAK,,Project VHAG-431, İzmir, 1982.

[140] Geldiay, R., "Akdeniz ve Ege de Bulunan Kaplumbağaların (Caretta c. ve Chelonia m.) Bugünkü ve Gelecek Durumları.VII.," in *VII. Tübitak Bilim Kongresi*, 1980.

[141] Geldiay, R., "Deniz Kaplumbağalarının (Caretta c. ve Chelonia m.) Korunmasında Temel Bilimler Yönünden Takip Edilecek Stratlıejinin Önemi.," in *I. Ulusal Deniz ve Tat su Araştırma Kongresi. Fen Fakültesi Dergisi*, 1983.

[142] Geldiay, R., "Situation of Sea Turtles on Aegean Sea and Mediterranean Sea Coasts of Turkey," in *Symposium of Concervation Strategies of Mediterranean Turtles (R.A.N.A.),* Tervuren, Belgium, 1988.

[143] Turkozan, O., Ilgaz, Ç., Taskavak, E., Özdemir, A., "Hatch rates of loggerhead turtles and physical characteristics of the beach at Fethiye, TURKEY," *Journal of Marine Biology,* vol. 83, pp. 231-232, 2003.

[144] Aymak, C.,Ergene, S., Kaska,Y., "Reproductive ecology of Caretta caretta and Chelonia mydasduring 2002 and 2003 nesting seasons in Alata, Mersin, Turkey," in *The second Mediterranean Conference on Marine Turtles Book of Abstracts 10*, Antalya, 2005.

[145] Ergene, S., Aymak, C., Bahadır, Ö., Güvel, Z., Elçi, A., Şengezer, N., "A Preliminary Research on Determining Potential Marine Turtle Nestng Activity

on Davultepe 100. Yıl Beach, Mersin," *Ege University Journal of Fisheries and Aquatic Sciences,* vol. 27, no. 1, pp. 7-13, 2010.

[146] Canbolat, A.F., "A Review of Sea Turtle Nesting Activity along the Mediterranean Coasts of Turkey," *Biological Conservation,* vol. 116, pp. 81-91, 2003.

[147] Canbolat, A.F., "A Review of Sea Turtle Nesting Activity along the Mediterranean Coasts of Turkey," *Biological Conservation,* vol. 116, pp. 81-91, 2003.

[148] Baran, I., Ilgaz, Ç., Türkozan, O., Kaska, Y., Kumlutaş, Y., "“Caretta caretta türünün Dalyan, Fethiye, Patara ve Kızılot Kumsalları'ndakiPopulasyon Durumlarının Arastırılması ve Koruma Stratejilerinin Saptanması”," in *IV. Ulusal Ekoloji Kongresi*, Bodrum- Muğla, 2001.

[149] Katılmis, Y. , Urhan, R, "Dalaman'da İribaş Kaplumbağa (Caretta caretta) Yuvalarında Görülen Bazı Omurgasızlar ve Bunların Yumurta ve Yavrular Üzerine Etkileri," in *Birinci Ulusal Deniz Kaplumbağaları Sempozyumu Bildiriler Kitabı,* 2003, 2003.

[150] Katılmis, Y., Urhan, R., Kaska, Y. , Baskale, E., "Invertebrate infestation on eggs and hatchlings of the loggerhead turtle (Caretta caretta), in Dalaman, Turkey," *Biodiversity and Conservation,* vol. 15, pp. 3721-3730, 2006.

[151] MacDonald, D. W., Brown, L., Yerli, S.,Canbolat, A. F., "The behaviour of red foxes, Vulpes vulpes catching the eggs of loggerhead turtles, Caretta caretta," *Journal of Mammalogy,* vol. 75, no. 4, pp. 985-988, 1994.

[152] Yerli, S., Canbolat, A. F., Brown, L. J., MacDonald, D. W., "Mesh grids protect loggerhead turtle Caretta caretta nests from red fox Vulpes vulpes predation," *Biological Conservation,* vol. 82, pp. 109-111, 1997.

[153] Ozdemir, A., Turkozan, O., Ilgaz, C., Martin, R., "Nest Site Factors and Invertabrate Infestation of Loggerhead Turtle Nests," *Israel Journal of Zoology,* vol. 50, pp. 333-340, 2004.

[154] Ozdemir, A., llgaz, Ç., Kumlutas, Y., Durmus, S.H., "Invertebrate Infestation of Caretta caretta Nests at Fethiye Beaches, Turkey," *Pakistan Journal of*

Biological Sciences, vol. 9, no. 3, pp. 507-513, 2006.

[155] Turkozan, O., Taskavak, E., Ilgaz, C., "A review on five major nesting beaches of loggerhead turtle, Caretta careta, on the southwestern Mediterranean coast of Turkey," *First Mediterranean Conference on Marine Turtles*, p. 2001, 24-28 October 2001.

[156] Ozdemir, A., Ilgaz, C., Kumlutas, Y., Durmus, S.H., Kaska, Y., Turkozan,O., "An Assessment of Initial Body Size in Loggerhead Sea Turtle (Caretta caretta) Hatchlings in Turkey," *Zoological Science*, vol. 24, no. 4, pp. 276-380, 2007.

[157] Turkozan, O., Ilgaz, C., Sak, S., "Carapacial scute variation in loggerhead turtles (Caretta caretta)," *Zoology in the Middle East*, vol. 24, pp. 137-142, 2001.

[158] Turkozan, O., Ilgaz, C., Ozdemir, A., Baran, I., Durmus, H., Kumlutas, Y., "Tasima ve Dogal Yuvalardaki Caretta caretta ve Chelonia mydas Yavrularında Karapastaki Plak Farklılaşmaları ve Boy-Ağırlık İlişkileri," in *Birinci Ulusal Deniz Kaplumbağaları Sempozyumu Bildiriler Kitabı*, İstanbul, 2003.

[159] Baskale, E., "Deniz Kaplumbaga (Caretta caretta L., 1758) Yuva Yerlerinin Degistirme Yontemiyle Korunması, Yuksek Lisans Tezi," P.A.Ü., Fen Biilimleri Enstitüsü, Denizli, 2003.

[160] Turkozan, O., Yılmaz, C., "Nest relocation as a conservation strategy: looking from a different perspective," *Marine Turtle Newsletter,* vol. 118, pp. 66-8, 2007.

[161] Kaska, Y., Furness, R.W., "Heavy metals in marine turtle eggs and hatchlings in the Mediterranean," *Zoology in the Middle East*, vol. 24, pp. 127-132, 2001.

[162] Sozbilen, D., "Investigtion of the some blood physiological parameters in loggerhead sea turtles," Pamukkale Üniversitesi Fen BilimleriEnstitüsü, Denizli, Türkiye, 2011.

[163] Turkozan, O., Durmus, S. H., "A Feeding Ground for Juvenile Green Turtles, Chelonia mydas, on the western Coast of Turkey," *The British Herpetological Society Bulletin*, vol. 71, pp. 1-5, 2000.

[164] Ozaner, S., "Kazanli (Mersin) ve Samandag (Antakya) Kıyıları’nda Kıyı (Plaj) Erozyonunun Arastirilmasi," Turkiye Bilimsel ve Teknik Arastirma Kurumu,

Deniz Bilimleri ve Balıkcilik Arastirma Grubu Proje No: DEBAG- 62, 50 s., Ankara, 1993.

[165] Oruc, A., DemirayaK,F., Sat, G., "Dogu Akdeniz'de trol balikciligi ve deniz kaplumbagaları uzerine etkisi. Sonuc Raporu," 1997.

[166] Oruc, A., Turkozan,O., Durmus,H., "In the Tracks of Marine Turtles: Assessment of Marine Turtle Nesting Sites 2003," WWF-Türkiye, İstanbul, 2003.

[167] Atabey, S., Taskavak, E., "A preliminary study on the prawn trawls excluding sea turtles," *E.U. Journal of Fisheries and Aquatic Sciences,* vol. 18, pp. 71-79, 2001.

[168] Cİtak, E. T., "An Investigation on the effects of different ecological conditions to the embriyological development of Marine Turtle Populations," D.E.Ü., Fen Bilimleri Enstitüsü, İzmir, 1998.

[169] Taskin, N., "Patara Kumsali'ndaki Deniz Kaplumbagasi Populasyonunun Embriyolojik Gelisiminin İncelenmesi, Yüksek Lisans Tezi," D.E.Ü., Fen Bilimleri Enstitüsü, İzmir, 1998.

[170] Kaska, Y., Downie, R., "Embryonic development of sea turtles in Mediterranean," *Zoology in Middle East,* vol. 19, pp. 55-69, 1999.

[171] Ozdemir, A., Ilgaz, C., "Monitoring and conservation project of the Soft Shelled Nile Turtle (Trionyx triunguis) and sea turtle (Caretta caretta, Chelonia mydas) populations at Fethiye-Göcek (Çalış beach) specially protected area," Turkish Ministry of Environment and Forestry, Environmental Protection Agency for Special Areas, Ankara, 2008.

[172] Taskin, N., Baran, I., "Reproductive ecology of the loggerhead turtle, Caretta caretta, at Patara, Turkey," *Zoology in the Middle East,* vol. 24, pp. 91-100, 2001.

[173] Turkozan, O., Durmus, S.H., "Albino loggerhead and green turtle (Caretta caretta and Chelonia mydas) hatchling in Turkey," *Zoology in the Middle East,* vol. 24, pp. 133-136, 2001.

[17 Aymak, C., Ergene, S., Kaska, Y., "Abnormality and Albino Marine Turtle

4] (Chelonia mydas) Hatchlings in Mersin, Turkey," in *26th Annual Symposium on Sea turtle Biology and Conservation*, Islands of Crete, Greece, 2006.

[175] Turkozan, O., Yilmaz, C., "Post-hatchling Loggerhead Turtles, Caretta caretta," *Eastern Mediterranean Marine Turtle Newsletter,* vol. 128, p. 24, 2010.

[176] Kaska, Y., Downie, R., Tippett, R., Fumess, R., "Natural temperature regimes for loggerhead and green turtle nests in the eastern Mediterranean," *Canadian Journal of Zoology,* vol. 76, pp. 723-729, 1998.

[177] Kaska, Y., "Predation pattern of loggerhead and green turtle nests in the Eastern Mediterranean and its possible effect on sex ratio," *Israel Journal of Zoology,* vol. 46, pp. 343-349, 2000.

[178] Kaska, Y., Ilgaz, Ç., Ozdemir, A., Baskale, E., Turkozan, O., Baran, I.,, "Sex Ratio Estimations of Loggerhead Sea Turtle Hatchlings by Histological Examination and Nest Temperatures at Fethiye Beach, Turkey," *Naturwissenschaften,* vol. 93, pp. 338-343, 2006.

[179] Kaska, Y., Gidis, M., Baskale, E., Katilmiş, Y., Urhan, R., "Deniz Kaplumbaga Yavru Cinsiyet Oranının Kulucka Sicaklik Analizi ve Gonad Histolojisiyle Arasitirilmasi," in *I. Ulusal Deniz Kaplumbağaları Sempozyumu*, İstanbul, 2003.

[180] Kaska, Y., Downie, J.R., Tippett, R.,Furness, R., "Natural temperature regimes for loggerhead and green turtle nests in the eastern Mediterranean," *Canadian Journal of Zoology,* vol. 76, pp. 723-729, 1998.

[181] Kaska, Y., "Predation pattern of loggerhead and green turtle nests in theeastern Mediterranean and its possible effect on sex ratio," *Israel Journal of Zoology,* vol. 76, pp. 723-729, 2000.

[182] Kaska, A., Bagci, H. ve Kaska, Y., "Genetic Material Collection of Sea Turtles and PCR Amplifications," in *The First Mediterranean Conference on Marine Turtles,* Roma, Italy, 2001.

[183] Yilmaz C., Turkozan, O., Bardakci, F., "Genetic structure of loggerhead," *Biological Systematics and Ecology turtle (Caretta caretta) populations in Turkey* , vol. 39, pp. 266-276, 2011.

[18 Oruc, A., Türkecan, O., Yerli, S., "Cirali, Maden Koyu, Beycik Buku, Boncuk

4] Buku, Kucuk Boncuk Koyu veTekirova Buku Kumsallari Deniz Kaplumbagasi (Caretta caretta) ve Yumusak Kabuklu Nil Kaplumbagasi (Trionyx triunguis) Populasyonlarinin Arastirilmasi, Izlenmesi ve Korunması Calismasi," *WWF TURKEY,* vol. 2, 2007.

[185] Ozdilek, S., Aureggi, M., "Strandings of juvenile green turtles at Samandağ," *Chelonian Conservation and Biology,* vol. 5, pp. 152-154, 2006.

[186] Godley, B.J., Richardson, S., Broderick, A.C., Coyne, M.S., Glen, F., Hays, G., "Long term satellite telemetry of the movements and habitat utilisation by green turtle in the Mediterranean," *Ecography,* vol. 25, pp. 352-362, 2002.

[187] Peters, A., Verhoeven, K.J.F., "breeding success of the loggerhead, Caretta caretta, and the green turtle, Chelonia mydas, in the Göksu Delta, Turkey," Department of Animal Ecology,University of Nijmegen, Nijmegen, 1992.

[188] Pigelen, D.S.G., Strijbosch, H., "The nesting of sea turtles (Caretta caretta and Chelonia mydas) in the Göksu Delta, June - August 1991," *Turkish Journal of Zoology,* vol. 17, pp. 137-149, 1993.

[189] Glen, F., Godley, B.J., Kelly,A., Broderick, A.C., "Marine turtle nesting in the Göksu Delta, Turkey, 1996," *Marine Turtle Newsletter,* vol. 77, pp. 17-19, 1997.

[190] Durmus, S.H., Ilgaz,C., Ozdemir, A., Yerli, S.V., "Nesting Activity of Loggerhead Turtles (Caretta caretta) at Göksu Delta, Turkey during 2004 and 2008 nesting seasons," *Ecologica Balkanica,* vol. 3, no. 1, pp. 95-106, 2011.

[191] Glen, F., Godley, B.J. , Kelly, A. , Broderick, A.C., "Marine turtle nesting in the Göksu Delta, Turkey, 1996," *Marine Turtle Newsletter,* vol. 77, pp. 17-19, 1997.

[192] Akcinar, S.C., "Deniz kaplumbagalarinin Goksu Deltasi'ndaki (Silifke, Mersin)2005 yili ureme aktiviteleri.Msc. Thesis.," Ege University Graduate School of Natural and Applied Sciences, İzmir, 2006.

[193] Canbolat, A.F., "Göksu deltası özel Çevre koruma bölgesinde denizka plumb a ğa s ı (Ca r e t t a c a r e t t a , Ch e lo n ia mydas) ve nil kaplumbağası (Tr io ny xtriunguis) p o p ula s y o n la r ın ın araşt ır ılması ve korunma sı," T. C. Çevre ve Orman Bakanlığı, Özel Çevre Koruma Kurumu, Mersin Özel Çevre Koruma Müdürlüğü, Mersin, 2006.

[194] Gokdaganer, "Göksu deltası özel çevre koruma bölgesinde deniz kaplumbağası (Caretta caretta, Chelonia mydas) ve nil kaplumbağası (Trionyx triunguis) populasyonlarının araştırılması ve korunması projesi," T.C. Çev r e v e Or ma n Ba ka n lığı, Öz el Çev r e Ko r uma Kur umu, Mer s in Öz el Çev r e Ko r uma Müdür lüğü, Mer s in, 2007.

[195] Aymak, C., "Biological properties of marine turtles (Caretta caretta ve Chelonia mydas) on Alata beach] (MSc Thesis)," Mersin University, Mersin, 2003.

[196] Aymak, C., Ergene-Gozukara, S., Kaska, Y., "Reproductive Ecology of Caretta caretta and Chelonia mydas during 2002 and 2003 nesting seasons in Alata, Mersin, Turkey.," in *Second Mediterranean Conference on Marine Turtles*, Antalya, 2005.

[197] Ergene, S., Aymak, C., Ucar A.H., Kacar, Yasemin, "The Research on the Population of Chelonia mydas and Caretta caretta Nesting on Alata Beach, Mersin," *Ege University Journal of Fisheries and Aquatic Sciences,* vol. 26, no. 3, pp. 187-196, 2009.

[198] Ergene, S., Aymak, C., Ucar, A.H., "Carapacial scute variation in green turtle and loggerheadturtle hatchlings in Alata, Mersin, Turkey," *Turkish Journal of Zoology,* vol. 35, no. 3, pp. 343-356, 2008.

[199] Kacar, Y., "Microsatellite Locus Analysis of Green Turtles (Chelonia mydas) of Alata Beach," *Gazi Eğitim Fakültesi Dergisi,* vol. 31, no. 1, pp. 247-260, 2011.

[200] Elmaz, C., Kalay, M., "The Breeding Success of Chelonia mydas and Caretta caretta on Kazanlı Beach," *Ekoloji,* vol. 58, no. 15, pp. 28-32, 2006.

[201] Bagda, E., "Population Genetic Structure of Green Turtle (Chelonia mydas) in the Northeastern Medditerranean, PhD Thesis," Cumhuriyet Universty Graduate Schoolof Natural and Applied Sciences Department of Biology, Sivas, 2009.

[202] Yilmaz, C., "Population Genetic Structure of the Loggerhead(Caretta caretta) in the Turkey,Ph.D. Thesis," Adnan Menderes Univercity, Aydın, 2012.

[203] Gossling, S., "Global environmental consequences of tourism," *Global Envirnmental Change,* vol. 12, no. 4, pp. 283-302, 2002.

[20 Atik, M., Altan, T., Artar, M., "Land Use Changes in Relation to Coastal

4] Tourism Developments in Turkish Mediterranean," *Polish Journal of Environmental Studies,* vol. 19, pp. 21-33, 2010.

[205] Hall, C.M., "Trends in ocean and coastal tourism: the end of the last frontier?," *Ocean and Coastal Management,* vol. 44, pp. 601-618, 2001.

[206] Baykan, N.M., "The Determining Effects of Land Uses in Coastal Areas of Seferihisar, Turkey," in *Annual Meeting of the International Association for Impact Assessment*, 2013.

[207] Sesli, F.A.,Karsli, F., "Monitoring Costal Land Use Changes on the Turkish Black Sea Cst with Remote Sensing: An Example for Trabozn, Turkey," *Coastal Zone Management,* pp. 1-10, 2003.

[208] Polat-Beken, C., Tolun, L., Avaz, G., Donertas, A., Ediger, D., Karakoc, F-T. and Tugrul, S., "http://www.symposcience.fr/exl-doc/colloque/ART-00002381.pdf," 2009. [Online]. [Accessed 26 December 2013].

[209] Odasi, Mersin Ticaret ve Sanayi, "Ekonomik Rapor," Mersin Ticaret ve Sanayi Odası, Mersin, 2013.

[210] Krom, M.D., Herut, B., Mantoura, R.F.C., "Nutrient Budget for the Eastern Mediterranean: ımplications of phosphorus limitation," *Limnological Oceanography,* vol. 49, no. 5, pp. 1582-1592, 2004.

[211] Markaki, Z., Oikonomou, K., Kocak, M., Kouvarakis, G., Chaniotaki, A., Kubilay, N., Mihalopoulos, "Atmospheric deposition of inorganic phosphorus in the Levantine Basin, eastern Mediterranean: Spatial and temporal variability and its role in seawater productivity," *Limnological Oceanography,* vol. 48, no. 4, pp. 1557-1568, 2003.

[212] Markaki, Z., Loye-Piilot, M.D., Violaki, K., Benyahya, L., Mihalopoulos, N., "Variability of atmospheric deposition of dissolved nitrogen and phosphorus in the Mediterranean and possible link to the anomalous sea water N/P ratio.," *Marine Chemistry,* vol. 120, pp. 187-194, 2010.

[213] Everard, M., Jones, L., Watts, B., "Have we negleted the societal importance of sand dune? An ecosystem services perspectives," *Marine Freshwater Ecosystems,* vol. 20, pp. 476-487, 2010.

[214] WWF, "Marine turtles: Global voyagers threatened with extinction," WWF International Species Programme, Godalming, UK, 2003.

[215] Hentati. M. A.,, "seaturtle," Regional Activity Centre for Specially Protected areas Mediterranean Action Plan-UNEP, 2001. [Online]. Available: http://www.seaturtle.org/mtn/archives/mtn93/mtn93p42.shtml. [Accessed 2014].

[216] Broderick, Anette C.; Glen, Fiona; Godley, Brendan J.; Hays, Graeme C., "Estimating the number of green and loggerhead turtles nesting annually in the Mediterranean," *ORYX,* 2002.

[217] Miller, J.D., Limpus, C.J.,Godfrey, M.H., "Nest site selection, oviposition, eggs, development, hatchling and emergence of loggerhead turtles," in *Biology and Conservation of Loggerhead Sea Turtles,* Washington D.C., Smithsonian Books, 2003, pp. 51-54.

[218] Wood, D.W., Bjorndal, K.A., "Relation of temperature, moisture, salinity, and slope to nest site selection in loggerhead sea turtles," *Copea,* vol. 1, pp. 119-128, 2000.

[219] Mortimer, J. A, "The influence of beach sand characteristics on the nesting behavior and clutch survival of green turtles (Chelonia mydas)," *Copea*, pp. 802-817, 1990.

[220] Wood, J.R., Wood, F.E., "Growth and digestibility for green turtle (Chelonia mydas) fed diets containing varying protein levels," *Aquaculture,* pp. 269-274, 1981.

[221] Ackerman, R. A., "The nest environment and the embryonic development of sea turtles," in *The biology of sea turtles,* Boca Raton, CRC Press, 1997, pp. 83-106.

[222] Diez, E.C., Ottenwalter, J.A., "Habitat Survey," in *Research and Management Techniques for Consernation of Sea Turtles,* Washington,DC, USA, IUCN/SSCMarineTurtleSpecialistGroup, 1999, pp. 50-54.

[223] "https://www.google.com/intl/tr/earth," google, 30 11 2014. [Online].

[224] Varela-Acevedo, E., Eckert, K.L., Eckert, S.A., Cambers, G., Horrocks, J.A., "Sea Turtle Nesting Beach Characterization Manual," in *Examining the Effects*

of Changing Coastline Processes on Hawksbill Sea Turtle (Eretmochelys imbricata) Nesting Habitat, Master's Project, Beaufort, N. Carolina, icholas School of the Environment and Earth Sciences, Duke University, 2009, pp. 46-97.

[225] Pelling, M.,Uitto, J.I., "Small island developing states: natural disaster vulnerability and global change," *Environmental Hazards,* vol. 3, p. 49-62, 2001.

[226] Pachauri, R.K., Reisinger,A., "Contribution of Working Groups I, II and III," in *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Geneva, Switzerland, 2007.

[227] Parrish, A., Goodman, K., "Annual Report: Jumby Bay Hawksbill Project: Tagging and nesting research on hawksbill turtles (Eretmochelys imbricata) at Jumby Bay," WIDECAST for the Jumby Bay, Antigua, West Indies, 2006.

[228] Acevado, Varela; Elda; Eckert, Karen L.; Eckert, Scott A.; Cambers, Gillian; Horrocks, Julia A., "Sea Turtle Nesting Beach Characterization Manual," Nicholas School of the Environment and Earth Sciences, Beufort, N. Carolina USA., 2009.

[229] Southwood, T.R.E., Henderson, P.A., Ecological Methods, Oxford: Blackwell Science, 2000.

[230] Bancila, R.I.,Plaisu, R., "Sampling Efficiency of Pitfall Traps and Winkler Extractor for Inventory of the Harvestman (Arachnida: Opilionidae)," *Trav. Inst. Speol,* vol. XLVII, pp. 59-67, 2009.

[231] Ribelro-Junlor, M.A., Rossl, R.V., Mlaranda, R.V., Avila-Pres, T.C.S., "influence of pitfall traps size and design on herpetofauna and small mammal studies in a Neotropical Forest," *Zoologia,* vol. 1, pp. 80-91, 2011.

[232] Furnish, J., "Algae and Invertebrates of a Great Basin Desert Hot Lake: A description of the Borax Lake ecosystem of southeastern Oregon," in *Spring-fed Wetlands: Important Scientific and Cultural Resources of the Intermountain Region,* Vallejo, CA, 2002.

[23 Onset Company, "Onset Company," 13 May 2014. [Online]. Available:

3] http://www.onsetcomp.com/products/data-loggers/ua-002-64. [Accessed 13 05 2014].

[234] Bema Güvenlis Sistemleri, "D.CAM Güvenlik Sistemleri," 02 April 2011. [Online]. Available: http://www.d-cam.com.tr/index.php?route=product/product&product_id=171&search=beam. [Accessed 13 March 2014].

[235] Systems, Bosch Security, "Bosch Products," [Online]. Available: http://resource.boschsecurity.com/documents/AMAX_Alarm_Commercial_Brochure_plPL_16057298315.pdf. [Accessed 16 May 2014].

[236] "http://www.barcodinglife. org," 2014. [Online].

[237] Kimura, M., "Asimple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences," *Journal of Molecular Evolution,* vol. 16, pp. 111-120, 1980.

[238] Nei, M., Molecular Evolutionary Genetics, New York: Columbia University Press, 1987.

[239] Budki, P., Rani, S., Kumar, V., "Persistence of Circannual Rhythms under Constant Periodic and Aperiodic Light," *Journal of Experimental Biology,* 2012.

[240] Tamura, K., Peterson, D., Peterson, N., Stecher, G., Nei M., Kumar S., "MEGA5: Molecular Evolutionary Genetics Analysis using Maximum Likelihood, Evolutionary Distance, and Maximum Parsimony Methods," *Molecular Biology and Evolution,* vol. 28, pp. 2731-2739, 2011.

[241] Groombridge, B., "Marine turtles in the Mediterranean;Distribution, population status, conservation: A report to the Council of Europe," World Conservation Monitoring Centre, Cambridge, 1990.

[242] Kikuwaka, A., Kamezaki, N., Ota, H., "Factors affecting nesting beach selection by loggerhead turtles: a multiple regression approach," *Journal of Zoology,* 1999.

[243] Johannes, R.E., Rimmer, D.W., "Some distinguishing characterictics of nesting beaches of green turtle on North West Cape Peninsula, Western Australia,"

Marine Biology, vol. 83, 1984.

[244] Hays, G.C., MacKay, A., Adams, C.R., Mortimer, J.R., Speakman, J.R., Boerama, M., "Nest Site Selection by Sea Turtles," *Journal of the MarineBiological Association of the United Kingdom,* vol. 75, pp. 667-674, 1995.

[245] Yalçın-Ozdilek, S., Ozdilek, H.G., Ozaner, F.S., "Possible influence of beach sand characteristics on green turtle nesting activity on Samandağ Beach," *Journal of Coastal Research,* vol. 23, no. 6, 2007.

[246] Karavas, N., Georghiou, K., Arianoutsou, M.,Dimopoulos, D., "Vegetation and sand characteristics influencing nesting activity of Caretta caretta on Sekinia beach," *Biological Conservation,* vol. 121, 2005.

[247] Margaritoulis, D., "Nesting activity and reproductive output of loggerhead sea turtles, Caretta caretta, over 19 seasons (1984–2002) at Laganas Bay, Zakynthos, Greece: the largest rookery in the Mediterranean," *Chelonian Conservation and Biology,* vol. 4, no. 4, pp. 916-929, 2005.

[248] Unluata, U., Ozsoy, E., Latif, M.A., "On the variabilityof currents in the northeastern levantine sea," 1980.

[249] Reina, R.D., Mayor, P.A., Spotiila, J.R., Piedra, R., Paladino, F.V., "Nesting ecology of the leatherback turtle, Dermochelys coriacea, at Parque National Marino Las Bauas, Costa Rica: 1988- 1989 to 1999-2000.," *Copea,* vol. 3, 2002.

[250] Deidun, A., Pawley, A., Schembri, P.J., "Distribution and biology of two sympatric Phaleria species on Mealtese sand beaches," *Rapp. Comm. int. Mer. Medit.,* vol. 39, p. 737, 2010.

[251] Dickinson, C.H., Pugh, G.J.F., Biology of the Plant Litter Decomposition, London: Academic Press, 1974.

[252] Saji, A., Al Dhaheri, S.S., "Ecological Distribution and Seasonality of Darkling Beetles (Coleoptera: Tenebbrionidae) in the Western Region of Abu Dhabi," *Middle East J.Sci,* vol. 9, no. 6, pp. 704-710, 2011.

[253] Draney, M.L., "The subelytral cavity of desert the study sites from September to December, therefore, Tenebrionids," *Florida Entomologist,* vol. 76, no. 4, pp. 1-

11, 1993.

[254] Gotelli, N.J., "Ant Lion Zones: Causes of high-density predator aggregations," *Ecological Society of America,* vol. 74, pp. 226-237, 1993.

[255] Conner, J., Einer, T., "Capture of bombardier beetles by ant lion larvae," *Psche,* vol. 90, pp. 175-178, 1983.

[256] Wheeler, W. M., Demons of the dust., New York: W. W. Norton and Co, 1930.

[257] Levente, A., "Pit building ant-lion larvae effect to the distribution of the substrate particles in their microhabitats," *Natura somogyiesis,* vol. 9, pp. 167-185, 2006.

[258] Taiti, S. and Ferrara, F., "The terrestrial Isopoda of Corsica (Crustacea, Oniscidea)," *Bulletin du Museum national d'Histoire naturelle,* vol. 18, pp. 459-545, 1996.

[259] Roberts M. J., Collins Field Guide Spiders of Britain & Northern Europe, London: Harper Collins, 1995.

[260] Wolda, H., "Similarity Indices, Sample Size and Diversity," *Oecologia,* vol. 50, pp. 296-302, 1981.

[261] Verberk, W. C. E.P., Duinem, G.J.A., Peeters, T. M .J ., Esselink, H., "Importance of variation in water-types for water beetle fauna (Coleoptera) in Korenburgerveen, a bog remnant in the Netherlands," *Proc. Exp. Appl. Entomol.,* vol. 12, pp. 121-128, 2001.

[262] Ergene, S., Aymak, C., Ucar, A.H., Sengezer, N., Yasar, U., Kacar, Y, Kaya, S., "Alata Kumsalinda Uzun Donem Deniz Kaplumbagalari Çalısmalari 2002-2009," in *III. Ulusal Deniz Kaplumbağaları Sempozyumu Özet Kitapçığı,* Mersin, 2009.

[263] Limpus, C.J., "The southern oscillation regulates the annual numbers of green turtles (Chelonia mydas) breeding around northern Australa," *Australian Journal of Wildlife Research,* vol. 15, pp. 157-161, 1987.

[264] Kasperek, M., Godley, B.J., Broderick, A.C., "Nesting of the Green Turtle, Chelonia mydas, in the Mediterranean: a review ofstatus and conservation

needs," *Zoology in the Middle East*, vol. 24, no. 1, pp. 45-74, 2001.

[265] Weishampel, J. F., Bagley, D. A., Ehrhart, L. M., Rodenbeck, B. L., "Spatiotemporal patterns of annual sea turtle nesting behaviors along an East Central Florida beach," *Biological Conservation*, vol. 110, pp. 295-303, 2003.

[266] Kamel, S.J., Mrosovsky, N., "Nest site selection in leatherbacks : individual patterns and their consequences selection in leatherbacks," *Animal Behavior*, vol. 68, 2004.

[267] Godley, B.J., Broderick, A.C., Hays, G.C., "Nesting of green turtles (Chelonia mydas) at Ascension Island," *Biol. Conserv.*, pp. 151-158, 2001.

[268] Erhart, L.M., "Threatened and endangered species of the Kennedy Space Center,NASA Contract Report," National Aeronautics and Space Administration, JohnF. Kennedy Space Center, Florida, 1980.

[269] Sengezer, S. N., "Biological properties of populations of marine turtles [Chelonia mydas (Linnaeus, 1758) and Caretta caretta (Linnaeus, 1758)] on Kazanlı nesting beach, MSc Thesis," Mersin University, Mersin, 2012.

[270] Marquez, R, "Resultados preliminares sobre edad y crecimiento de la tortuga lora, Lepidochelys kempi (Garman)," in *Memorias IV Congreso Nationalde Oceanografia*, Mexico, 1972.

[271] Hughes, G.R., "The sea turtles of South-east Africa II," South African Ass. Marine Biol. Res, Durban, South Africa, 1974.

[272] Stickney, R.R.,White, D.B., Perlmutter, D., "Growth of green and loggerhead sea turtles in Georgia on natural and artificial diets," *Bull.*, vol. 31, pp. 37-44, 1973.

[273] Nuitja, I.N.S.,Uchida, I., "Preliminary studies on the growth and food consumption of thejuvenile loggerhead turtle (Caretta caretta L.) in captivity," *Aquaculture*, pp. 157-160, 1982.

[274] Zug, G.R., Wynn, A.H., Ruckdeschel, C., Age Determination of Loggerhead Sea Turtles, Caretta caretta,by Incremental Growth Marks in the Skeleton, Washington: SMITHSONIAN INSTITUTION PRESS, 1986.

[27 Erhart, L.M., "A review of sea turtle reproduction," in *Biology and Conservation*

5] *of Sea Turtles*, Washington D.C., Smithsonian Institution Press, 1982, pp. 29-38.

[276] Frazer, N.B., Richardson, J.I., "Annual variation in clutch size and frequency for loggerhead turtles, Caretta caretta, nesting at Little Cumberland Island, Georgia, USA.," *Herpetologica,* vol. 41, pp. 246-251, 1985.

[277] Bjorndal, K.A.,Carr,A., "Variation in Clutch Size and Egg Size in the Green Turtle Nesting Population at Tortuguero,Costa Rica," *Herpetologica,* vol. 45, pp. 181-189, 1989.

[278] Tiwari, M., Bjorndal, K.A., "Variation in morphology and reproduction in loggerheads, Caretta caretta, nesting in the United States, Brazil and Greece," *Herpetologica,* vol. 56, no. 3, pp. 343-356, 2000.

[279] Dodd, C.K., "Synopsis of the biological data on the Loggerhead Sea Turtle Caretta caretta(Linnaeus 1758)," in *Biological Report*, Washington, D.C., US Fish and Wildlife Service, 1988, pp. 1-1109.

[280] Nelson, M.J., Thompson, M.B., Pledger, S., Keall, S.N., Daugherty, C.H..

[281] (NRC), National Research Council, Decline of the sea turtles:causes and prevention, Washington,DC: National Academy Press, 2002.

[282] Packard, G.C., Packard, M.J., "The physiological ecology of reptilian eggs and embryos," in *Biology of Reptilia*, New York, New York Press, 1988, pp. 523-605.

[283] Needham, J., Biochemistry and morphogenesis, Cambridge: Cambridge University Press, 1966.

[284] McGehee, M.A., E¡ects of moisture on eggs and, "Effects of moisture on eggs and hatchlings of loggerhead sea turtles (Caretta caretta)," *Herpetologica,* vol. 46, pp. 251-258, 1990.

[285] Raymond, M., Schubert, J., Rainbow, B., "A non-invasive approach to documenting human interactions with nesting sea turtles," BARRIER ISLAND CENTER, Florida, 2012.

[286] E.O., Keith, "Boater Manatee Awareness System," Nova Southeastern University, Oceanographic Center, Florida, 2012.

[287] Eskew, T., "Best Management Practices for reducing Coyote Depradation on Loggerhead Sea Turtles in South Carolina," Clemson University, TigerPrints, South Carolina, 2012.

[288] Geller, AG., "Notes on the Nesting Ecology of Ouachita Map Turtles (Graptemys ouachitensis) at Two Wisconsin Sites Using Trail Camera Monitoring," *Chelonian Conservation and Biology*, vol. 11, no. 2, pp. 206-213, 2012.

[289] Sherley, B.R., Burghardt, T., Barham, J.P., Campbell, N., Cuthill, "Spotting the difference: towards fully- automated population monitoring of African penguins Spheniscus demersus," *Endangered Species Research*, vol. 11, pp. 101-111, 2010.

[290] Tomas, J., Gozalbes, P., Raga, A.J., Godley, B.J., "Bycatch of loggerhead sea turtles: insights from 14 years of stranding data," *Inter Research*, 2008.

[291] Antonello, S., Lucchetti, A., "An overview of loggerhead sea turtle bycatch and technical mitigation measures in the Mediterranean Sea," *Rev Fish Biol Fisheries*, 2010.

[292] Casale, P., "Sea turtle by-catch in Medditerranean," *Fish and Fisheries*, 2011.

[293] Dantec, "PIV," 2006. [Online]. Available: www.blabla.com. [Accessed 10 August 2012].