UNIVERSITÀ DEGLI STUDI DI PADOVA
Department of Comparative Biomedicine and Food Science

First Cycle Degree (B.Sc.)
in Animal Care

Conservation Strategies for Safeguarding Sea Turtle Nesting Beaches in the Mediterranean

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I feel honoured and humbled to be standing here, carrying forward the dreams that I have always worked towards. Now a step closer to making a difference in the lives of animals all around the world. I will carry this degree with honour!

“For most of history, man has had to fight nature to survive; in this century, he is beginning to realise that, in order to survive, he must protect it.”

Jacques-Yves Cousteau

Summary

The loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) turtles rely on Mediterranean coastal beaches for nesting in order to complete their life cycle. Maintenance and protection of these sites is essential not only for nesting females but also for the hatchlings taking their first steps into the water. This dissertation explores the life cycle, in particular the nesting period, of the two resident species of sea turtles while examining the Mediterranean nesting sites and highlighting the factors that are crucial for their conservation. Geographical positions of the sites are considered, as different coastal regions comply with their own regulations and management frameworks.

These habitats face natural and anthropogenic threats, posing significant challenges for survival of these species. Key threats investigated include climate change, shifting nesting patterns, predation, parasites and diseases, light pollution, poaching and coastal development. A review of legislations, public engagement projects and nest monitoring programs is conducted. Furthermore, it summarises the current conservation strategies aimed at providing the highest level of animal care to sea turtles instinctively returning to Mediterranean beaches. Throughout, it considers perspectives of different stakeholders, including animals themselves, animal caretakers, rescue centres, the tourism industry and the general public.

This dissertation addressed two main questions; What are the primary threats to sea turtle nesting beaches in the Mediterranean? How effective are the current conservation efforts, and what strategies could improve them? While answering these questions, the dissertation dives into existing projects and policies, assessing their effectiveness and identifying opportunities for improving animal welfare on these sites.

Finally, the following research proposes targeted conservation strategies and introduces a comparative table outlining region-specific conservation needs, contributing to the ongoing efforts to safeguard Mediterranean sea turtle nesting sites for future generations.

1. Introduction

Among the seven sea turtle species, the loggerhead *(Caretta caretta)* and the green turtle *(Chelonia mydas)* are the two primary ones that nest in the Mediterranean and are the main focus throughout this dissertation. Although occasional visits of the leatherback turtle *(Dermochelys coriacea)* are recorded, for the purpose of a more accurate analysis it is excluded from this study and, most importantly, it does not nest in the Mediterranean. The Mediterranean coastline plays a major role in the life cycle of these species, serving as critical nesting grounds where females return to lay their eggs. Boarded by 21 countries and spanning across 46,000 km, the Mediterranean region is further subdivided into, starting from east to west, Levantine Basin, Aegean sea, Ionian sea, Adriatic sea, Tyrrhenian sea, Balearic sea and Alboran sea.

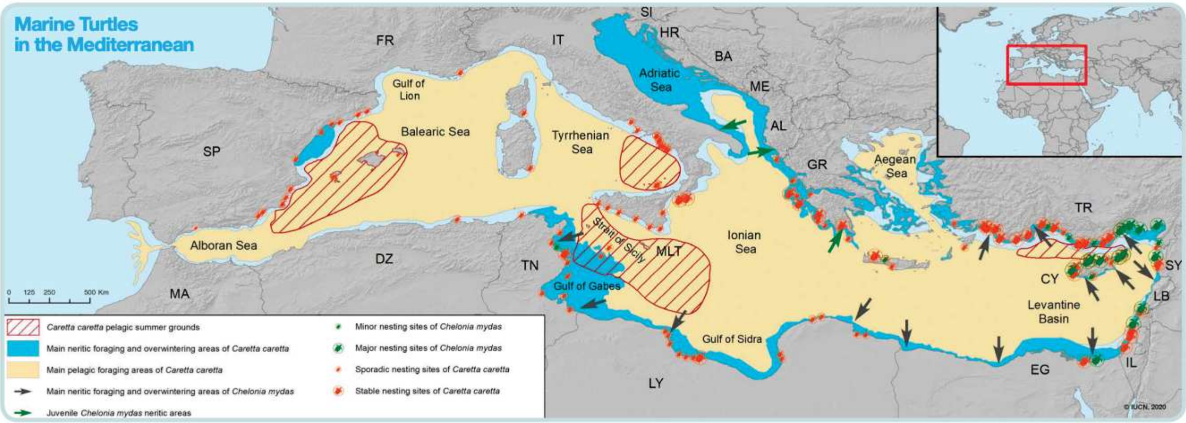


Fig. 1.0 [Distribution of marine turtle habitats and nesting sites in the Mediterranean Sea. Camiñas et al., 2020]

The loggerhead and the green turtle species are part of the Cheloniidae family, the so-called "hard-shelled sea turtles". All species that belong to the Cheloniidae family share similar anatomical traits. They are characterized by a bony carapace and a well-developed keratinous beak, distinguishing them from the other marine turtle family, the Dermochelyidae, which includes the leatherback turtle that lacks the bony shell. The major species differentiation is observed through the number of pairs and symmetry of lateral scutes. In fact, the Cheloniidae family is further divided into two subfamilies based on the number of pairs of the lateral scutes:

- ➔ **The Cheloniidae subfamily** represented by the green turtle *(Chelonia mydas)* and hawksbill turtle (*Eretmochelys imbricata*) are observed to have four pairs of lateral scutes.
- ➔ **The Carettinae subfamily** represented by the Loggerhead turtle *(Caretta caretta)* and the Kemp's Ridley (*Lepidochelys kempii*) turtle are observed to have five pairs of lateral scutes, and the Olive Ridley turtle (*Lepidochelys olivacea)* with six and above pairs of asymmetrical lateral scutes.

The loggerhead is the most common and abundant sea turtle species inhabiting the Mediterranean and its global population is listed as “Vulnerable [VU]” in the International Union of Conservation of Nature (IUCN) Red List with the last assessment evaluated in 2015 (Casale, 2015). There are ten Loggerhead subpopulations worldwide: NorthWest Atlantic Ocean, North East Atlantic Ocean, South West Atlantic Ocean, Mediterranean Sea, North East Indian Ocean, North West Indian Ocean, South East Indian Ocean, South West Indian Ocean, North Pacific Ocean, and South Pacific Ocean (Casale & Tucker, 2017). Meanwhile the global population of this species is declining worldwide according to sources, the Loggerhead numbers are increasing in the Mediterranean waters and the species in this region are listed as “Least Concern [LC]”. It is important to take into account all the subpopulation trends to truly understand the current status of this species. Due to the absence of exact adult counts, estimates mainly rely on known nesting sites and average clutch sizes. While this is not an accurate representation of the total number of animals and their conservation status, this allows for an estimate to work with.

In contrast, the green turtle is listed as “Endangered [EN]” worldwide, with a declining population trend, with the last assessment completed in 2004 (Seminoff, 2023). However, given that the last evaluation was conducted over twenty years ago, alternative indicators must be considered to accurately assess the status of this species. There are six Green turtle subpopulations: Central South Pacific, East Pacific, Hawaiian, Mediterranean, North Indian Ocean, South Atlantic and Southwest Indian Ocean. Unlike the loggerhead turtle, the green turtle Mediterranean subpopulation status remains poorly studied.

Despite their ecological significance, both the loggerhead and green turtle populations face numerous anthropogenic and natural threats, including habitat loss, climate change, predation, exposure to parasites and diseases and man made obstacles on nesting sites (Wallace et al., 2011). The loss of nesting beaches due to coastal development disrupts their reproductive cycles, while rising sea levels and temperature fluctuations caused by climate change influence hatchling sex ratios and survival rates (Hawkes et al., 2009).

This study aims to contribute to ongoing conservation efforts by addressing the following questions:

- Which are the major threats to sea turtle nesting beaches in the Mediterranean?
- How effective are current safeguarding measures for nesting sites and what new or improved strategies can be implemented?

The Loggerhead *(Caretta caretta)* and Green turtle *(Chelonia mydas)* rely on Mediterranean coastal beaches for nesting. This dissertation examines all factors threatening nesting and reproduction and evaluates the effectiveness of current conservation strategies in mitigating natural and anthropogenic threats such as climate change, habitat loss, and human disturbance. By taking into consideration perspectives of all stakeholders involved, from animal care technicians to local communities and to sea turtles themselves, this research aims to propose adaptive strategies that will contribute to the conservation of these marine reptiles. Only peer-reviewed articles and studies were included in the analysis of this dissertation to ensure scientific tone and reliability. Research databases such as ResearchGate, PubMed, and ScienceDirect were used to gather relevant literature and research papers. Additionally, sources referenced throughout this dissertation include independent research studies and reports from sea turtle conservation organisations, such as the Wider Caribbean Sea Turtle Conservation Network (WIDECAST), the State of the World's Sea Turtles (SWOT), and the International Union for Conservation of Nature (IUCN) Marine Turtle Specialist Group. The legislative frameworks and policies discussed in this dissertation were obtained directly from official government websites and regulatory bodies to ensure accuracy and up to date legal references.

2. Taxonomy

2.1 The Loggerhead Turtle (*Caretta caretta*)

Sea turtle identification, from external characteristics, is based upon the scales on the head, form of the jaws, the number of claws on the flippers, and the numbers and arrangement of the plates or scutes on the dorsal part of the shell (Wyneken, 2001). The scutes, or keratinous plates, on the dorsal surface of the shell are numbered from anterior to posterior (front to back). Among these, the costal scutes, which are positioned laterally on the carapace, are particularly crucial in distinguishing between the species of sea turtles in Mediterranean populations.

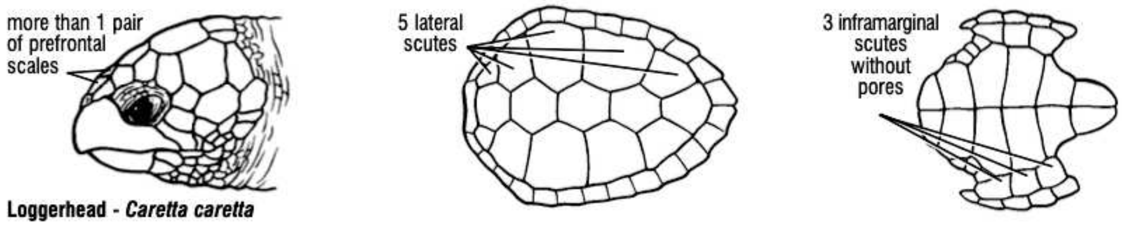


Fig. 2.0 [The Anatomy of Sea Turtles, Wyneken, 2001]

Mediterranean loggerheads are the smallest specimens of this species in the world (Camiñas et al., 2020) and the most common in this region; they are distinguished by a large head and brown carapace with five, or occasionally four or six (Caracappa et al., 2016), lateral scutes and more than one pair of prefrontal scales above the beak (Wyneken, 2001). In hatchlings, the carapace is brown with various shades of grey and the plastron is creamy to brown. In juveniles to adults it is creamy and tan. The carapaces of juveniles develop streaks of yellow and tan. The nuchal scute (the marginal just dorsal to the neck) is in contact with the first lateral scute which can serve as a key identification mark. The scutes of juveniles may slightly overlap one another at their margins whereas in adults there is no overlap of scutes making it easier to identify. The carapace is primarily brown with occasional individuals retaining some tans or even black. Loggerheads have two claws on each limb that can also serve as a key identification mark. On average, the length at sexual maturity of Mediterranean loggerhead turtles is more than 70 cm of curved carapace length (CCL), and the length of juvenile to adult turtles ranges from 16.8 cm to 97.5 cm CCL (Casale et al., 2011). In comparison to other loggerhead populations worldwide, a distinctive characteristic of the Mediterranean loggerhead is the relatively smaller size of adult females (Tiwari & Bjorndal, 2000).

2.2 The Green Turtle (*Chelonia mydas*)

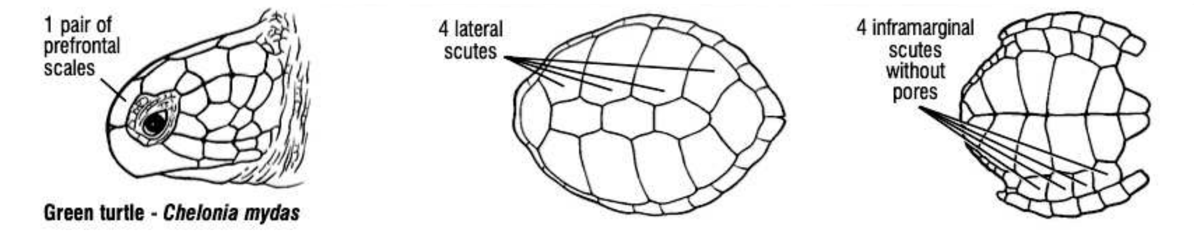
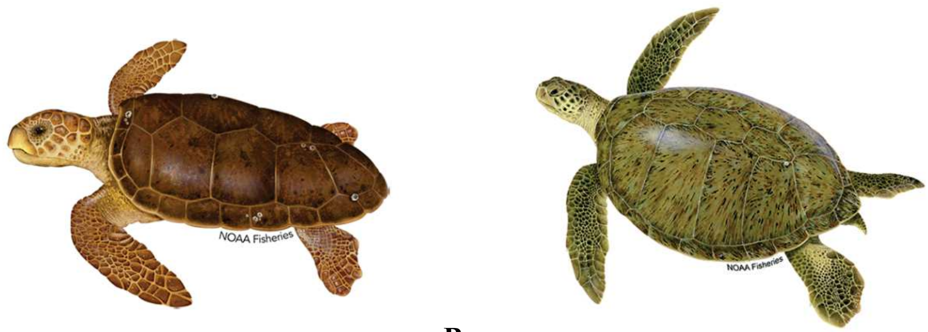


Fig. 2.1 [The Anatomy of Sea Turtles, Wyneken, 2001]

The Green turtle has one pair of prefrontal scales. They have one claw on their limbs. The carapace is smooth with 4 pairs of lateral scutes. Carapace color changes with age. It is black in hatchlings, then turns brown and tan in juveniles, and in adults, it is olive or gray-green, sometimes with speckles of yellow and brown (Wyneken, 2001). Hence acquiring its name due to this gradual change in coloration - the green turtle. The length of an adult green turtle on average is 86.9 cm (± 6.14), with the minimum length at maturity recorded in the east Mediterranean being 72 cm (Sönmez, 2019).



A **B**

Fig. 2.2 [A.Loggerhead turtle *(Caretta caretta)* B. Green turtle *(Chelonia mydas)*; NOAA fisheries]

Thus, in addition to variations in carapace coloration, the two species also differ in the number of prefrontal, lateral, and inframarginal scutes. Another factor of identification, that is not easily detectable without precise measurement instruments, are the lengths of the carapace and the approximate weight of each animal. The loggerhead is slightly smaller and lighter than the green turtle.

3. Life cycle

First, in order to evaluate the challenges sea turtles face on the nesting beaches, it is important to understand where nesting fits into their life cycle.

Sea turtles are slow growing, late maturing and long lived reptiles. The first years are currently being investigated through satellite tracking and more information is gathered year by year, however for a long time they were referred to as "The Lost Years". The ongoing research continues to refine our understanding of the first years of the sea turtles. After hatchlings enter the water, they drift around the algae and feed along ocean currents. These so-called "lost years" are in fact the period in which hatchlings drift along the currents that provide a thermal benefit to support growth, foraging and survival, after they get dispersed in the open ocean (Mansfield et al., 2014). As juveniles mature, they gradually move closer to coastal areas where they start feeding close to coral reefs and seagrass meadows, on benthic preys or an algae. Periodically, mature female turtles find their way back to the area where they were hatched and nest there. Males migrate every year towards reproductive sites, located close to nesting beaches, while females migrate to reproduce and nest every two to three years. Nesting is energy consuming, hence the difference in migration periods. They may reach anywhere from 12 to 40 years before they breed for the first time, that is when attaining carapace curve length (CCL) of around 70 cm. Once mature, a female nests for two decades or more (Choi & Eckert, 2009). Nesting behaviour is stereotypic, meaning that among species it does not change and the loggerhead and green turtle will exhibit the same nesting patterns. During nesting which usually takes place at night, females deposit clutches of eggs in carefully constructed nests, with an incubation period of approximately 60 - 70 days before hatching occurs (Choi & Eckert, 2009).

3.1 Nesting Ecology

Nesting season on Mediterranean coasts is from May to September. As sea turtles mature, females return to their natal beaches for nesting, a phenomenon known as "Natal Homing". This transition from neritic foraging habitats to reproductive sites marks a crucial stage in their reproductive cycle, emphasising the importance of safeguarding nesting beaches. It is believed that homing mechanism relies on a combination of cues, such as earth's magnetism, the position of the sun and star and oceans temperatures and currents (Choi & Eckert, 2009). Having found a suitable nesting site, a nest cavity is dug with the rear flippers and 50 - 200 eggs (usually referred to as "clutch size") are laid and covered with sand. The nest will have a depth of approximately 50 - 80 cm. This will typically occur two to six times per year with an interval of 9 - 15 days, depending on the species, and this cycle is repeated after two to five years (Choi & Eckert, 2009). A sea turtle may lay over a thousand eggs in its life cycle: with an estimation that 1 in 1000 hatchlings will survive to maturity and reproduce again (Choi & Eckert, 2009).

Monitoring nesting sites is the most accurate way to estimate the population size of any sea turtle species, due to ethical and practical constraints. It is important for monitoring population conservancy as well as for measuring the efficacy of protection policies. It is important for population monitoring. Identifying the location of the nest can be done by observing turtle tracks on the sand. Rescue centres and independent organisations working to monitor nesting sites can examine the width and symmetry of the tracks to identify what species the nest belongs to. “False crawls” representing unsuccessful attempts at nesting can be distinguished by abrupt turns and absence of a nest. The percentage of successful nesting events versus failed attempts can tell us a lot about the suitability of the nesting beach to act as a nesting site. The nesting beach may have obstacles that prevent the female from attempting to nest such as physical obstruction, bright lights and/or presence of people (Choi & Eckert, 2009).

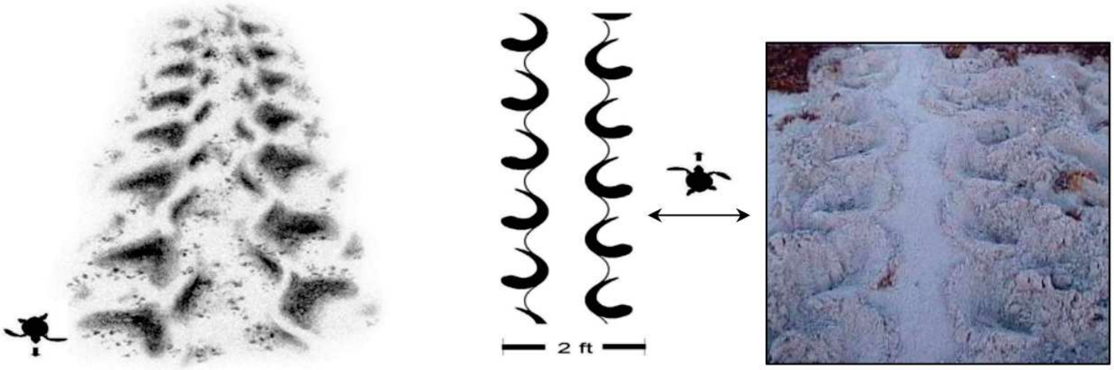


Fig 3.0 [Loggerhead turtle asymmetrical tracks. Track width (widest point) - 80-90cm. Source: Sea Turtle Conservation Guidelines (FFWCC 2007)]

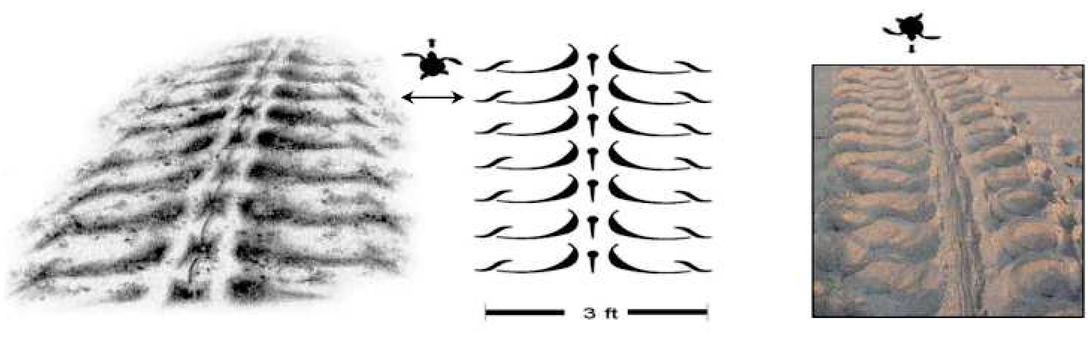


Fig. 3.1 [Green turtle turtle symmetrical tracks. Track width (widest point) - 70-130 cm. Source: Sea Turtle Conservation Guidelines (FFWCC 2007)]

Monitoring false crawl rates provides valuable insights into nesting site suitability and the extent of human disturbance. High false crawl rates may indicate unsuitable beach conditions, leading to lower reproductive success.

Once nesting is complete, the survival of the clutch depends on a variety of environmental and anthropogenic factors. Understanding hatchling emergence and their journey to the ocean is crucial in evaluating the overall reproductive success of these species and the obstacles they encounter on the way can help us identify the gaps that require improvement.

3.2 Hatchling Behaviour

Sea turtle clutches receive no parental care and hatchlings rely on instincts for survival. The sex of the hatchlings is determined by the incubation temperature, a phenomenon known as temperature - dependent sex determination (TSD) (Standora & Spotila, 1985). Warmer temperatures result in a higher proportion of females, while cooler temperatures produce more males. When turtle's eggs incubate below 27.7° C, the turtle hatchlings will be male, while if above 31° C the hatchlings will be 100% female. Temperatures that fluctuate between the two extremes will produce a mix of male and female baby turtles (Standora & Spotila, 1985).

Once broken out of the egg, hatchlings work cooperatively to move out of the nest and instinctively move towards the sea, using the moonlight that's reflecting on the water or natural light of the horizon as a navigator. Instinctively they swim directly into incoming waves and navigate their way towards a current. Despite strong instincts, it is estimated that only 1 in 1000 of the hatchlings survive to adulthood after reaching open water, with many affected by high predation and other environmental and/or anthropogenic factors. Beyond these immediate threats, environmental pollutants pose a significant risk to hatchlings. Chemical pollutants could weaken hatchlings or disrupt embryonic development. Additionally, toxic elements transferred from females to eggs, such as metal bioaccumulation, can impact hatchling survival and reproductive success (Serra et al., 2023).

Understanding the full scope of threats hatchlings face is the first step towards developing effective conservation strategies that will contribute to the survival of these species. Given the high mortality rate of hatchlings, conservation efforts must focus on mitigating the threats present at nesting sites. The next section will examine key Mediterranean nesting locations and any occurring shifts in the nesting behaviour.

4. Nesting Sites

Before understanding the conservation measures that are needed in order to safeguard nesting beaches, nesting sites must first be identified. The nesting distribution and abundance of the loggerhead turtle and green turtle has for a long time been concentrated in the eastern and southern coastal regions with established nesting sites in Greece, Turkey (Broderick, 2002), Libya (Laurent, 1995) and Cyprus. However, recent studies suggest there has been an expansion of nesting distribution along the central and western Mediterranean coastlines. Sporadic nesting has been increasingly documented in new locations, including Italy, Spain, France, Algeria and Tunisia (Hochscheid et al., 2022). This expansion and shift is driven by a combination of climatic and ecological factors, including rising temperatures and shifts in oceanic currents (Simantiris, 2024), along with anthropogenic factors such as fishing bycatch or simply drifting away from its course. The reproductive success of Mediterranean sea turtles fundamentally relies on the availability of suitable nesting sites.

The IUCN (2020) map (Fig. 1.0) offers a comprehensive overview of the major nesting sites and foraging grounds of both the loggerhead turtle and green turtle throughout the Mediterranean region. It provides a visual representation of key coastal regions where nesting occurs. With stable nesting sites in Greece, Turkey and Libya for loggerheads and Cyprus along with parts of Turkey for green turtles (Annex, Figure A & Figure B). The map also illustrates neritic and pelagic foraging areas. It acts as a tool to recognise different habitats and various life stages of the sea turtles. Small juveniles mostly occupy specific oceanic grounds, while large juveniles, which have shifted their diet towards benthic preys, subadults and adults are observed on neritic grounds on the continental shelf.

4.1 Loggerhead turtle (*Caretta caretta*) Nesting Sites

The loggerhead turtle tends to nest throughout several Mediterranean regions, with highest concentrations found in Greece, Turkey and Libya and the species have started to expand their nesting range into the Western Mediterranean, including Spain, Italy and France, which until recently was observed to host only sporadic nests (Hochscheid et al., 2022). This shift in geographical distribution is mostly due to climate change that has led to increased sea surface temperatures (Simantiris, 2024).

4.1.1 Major Nesting Sites

Greece holds the most important nesting coasts for loggerhead turtles in the Mediterranean. Southern Kyparissia Bay is the most abundant nesting site with an average of 1403 nests per year and with a length of 9.5 km. Other major nesting areas in Greece include Laganas Bay (Zakynthos island) and Rethymno (Crete island). Important to highlight, that the length of a nesting site does not necessarily correspond to a higher annual nest count. For example, the Göksu Delta in Turkey spans up to 34.7 km yet only averages 124 nests per year according to the IUCN 2020 report (Camiñas et al., 2020).

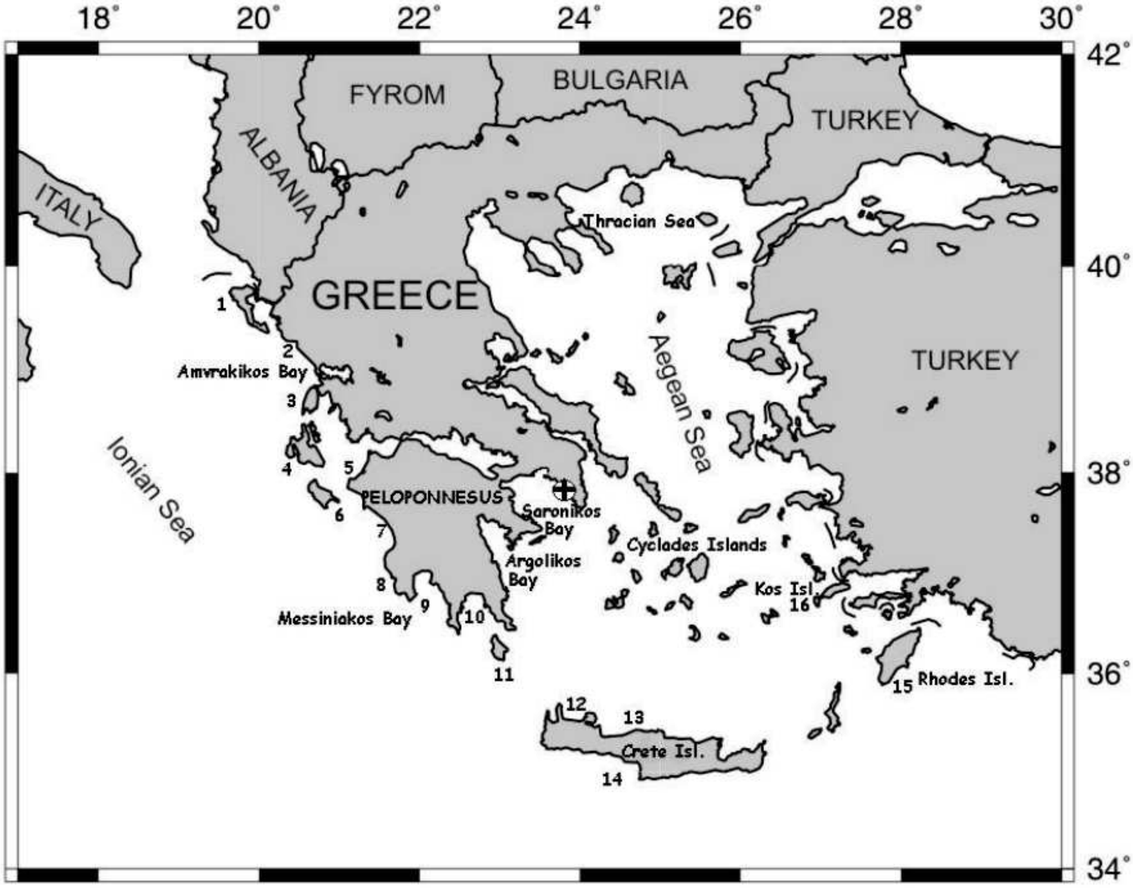


Fig. 4.0 [1: Kerkyra Isl., 2: Ipirus coast, 3: Lefkas Isl., 4: Kefalonia Isl., 5: Kotychi, 6: Zakynthos Isl., 7: Kyparissia Bay, 8: Romanos, 9: Koroni, 10: Lakonikos Bay, 11: Kythira Isl., 12: Bay of Chania, 13: Rethymno, 14: Bay of Messara, 15: Rhodes Isl., 16: Kos Isl.; Loggerhead sea turtle major nesting sites identified by Casale & Margaritoulis (2010)]

Second with the highest abundance of nests per year is Turkey, a coastline that hosts multiple important loggerhead nesting beaches, with the highest nesting densities recorded in Anamur, Belek, Dalyan and Kizilor (in descending order of average nests/year). Geldiay (1984) conducted the first study to determine nesting grounds of Turkey between 1979 and 1982 and established 16 nesting sites of the Turkish Mediterranean coast; Koycegiz, Fethiye, Kas, Finike, Kumluca, Kemer, Antalya, Serik, Side, Alanya, Gazipasa, Silifke, Mersin, Tuzla, Karatas and Yumurtalik regions. Earlier studies by Canbolat (2004) identified Dalyan (11.9%), Kumluca (11.3%), Belek (27.9%), Kizilot, (8.9%) and Anamur (8.8%) as the most significant nesting sites for loggerheads, while Kazanli (24.1%) and Akyatan (54.4%) were identified as the green turtles major nesting sites (Canbolat, 2004), which will be elaborated more further on. Previously, Koycegiz, Finike, Antalya and Serik regions were recorded as important nesting grounds for the loggerhead (Baran and Kasparek, 1989). The IUCN database reflects slight shifts in these statistics, with Anamur now being the most abundant beach in terms of average nests per year. Previous and current studies demonstrate the statistical evidence that sea turtles experience dynamic changes in nesting site selection over time, likely influenced by coastal development, temperature shifts and conservation efforts.

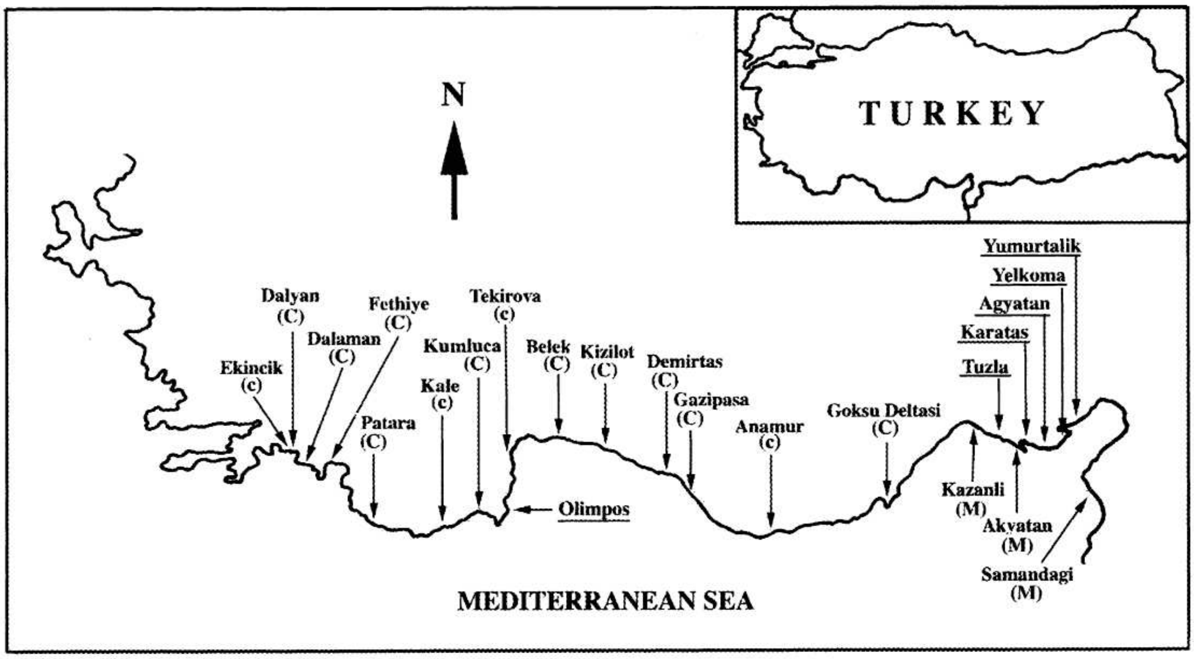


Fig. 4.1 [Sea turtle nesting sites in Turkey; C: High density for the loggerhead turtle, c: Low density for loggerhead turtle, M: High density for the green turtle; Baran and Kasparek, 1989 for High and Low density sites & Canbolat, 2004 for newly identified underlined sites]

Between 2010 and 2020 the nesting had expanded to coasts of Spain, Italy, France and Tunisia. The number of recorded nests has increased since 2013 from 1 to 3 nests/year, with a record number of 84 nests registered in 2020 (Fig. 4.2).

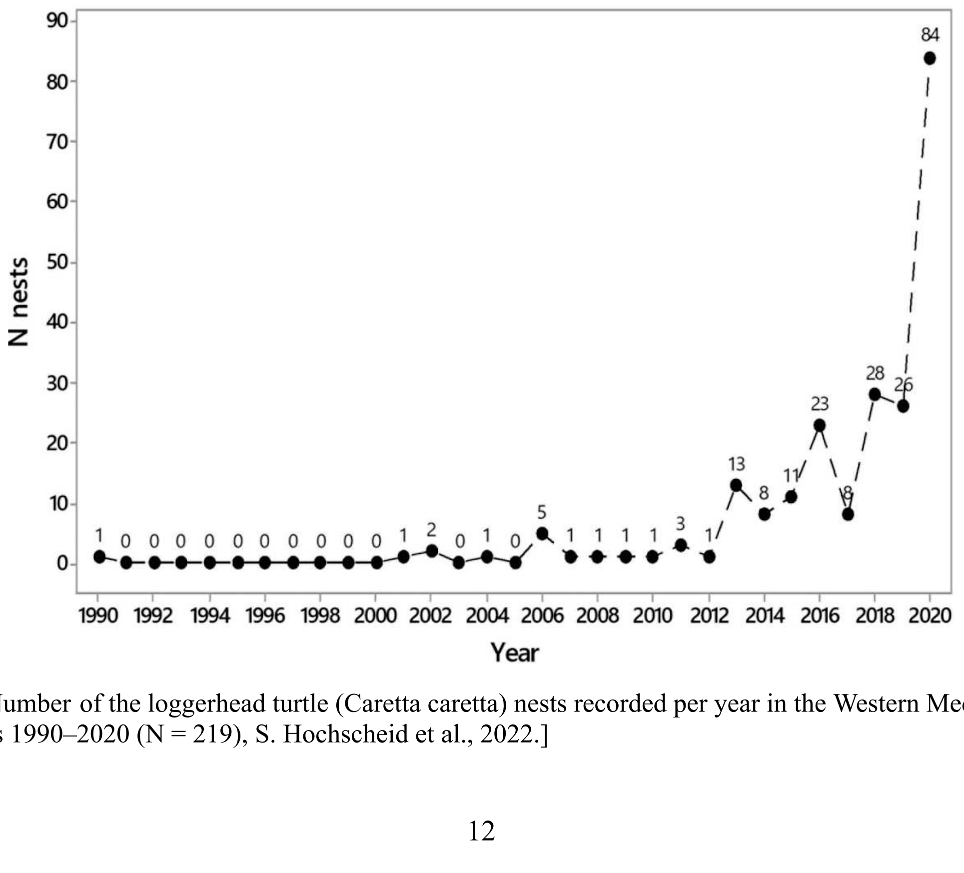


Fig. 4.2 [Number of the loggerhead turtle (Caretta caretta) nests recorded per year in the Western Mediterranean in the years 1990–2020 (N = 219), S. Hochscheid et al., 2022.]

This increase could be partly explained by the increased public awareness and improved reporting of the nesting events. Regardless, there is no doubt of an upwards trend in nesting activity (Hochscheid et al., 2022) that represents the biological shift in nesting behaviour. Hochscheid et al. (2022) documented a total of 206 loggerhead turtle nests in the Western Mediterranean between 2010 and 2020 (Fig. 4.2). These nests are unevenly distributed, with the highest concentrations along the warmer Tyrrhenian Sea, particularly along the coasts of Toscana, Lazio and Campania regions (south Italy).

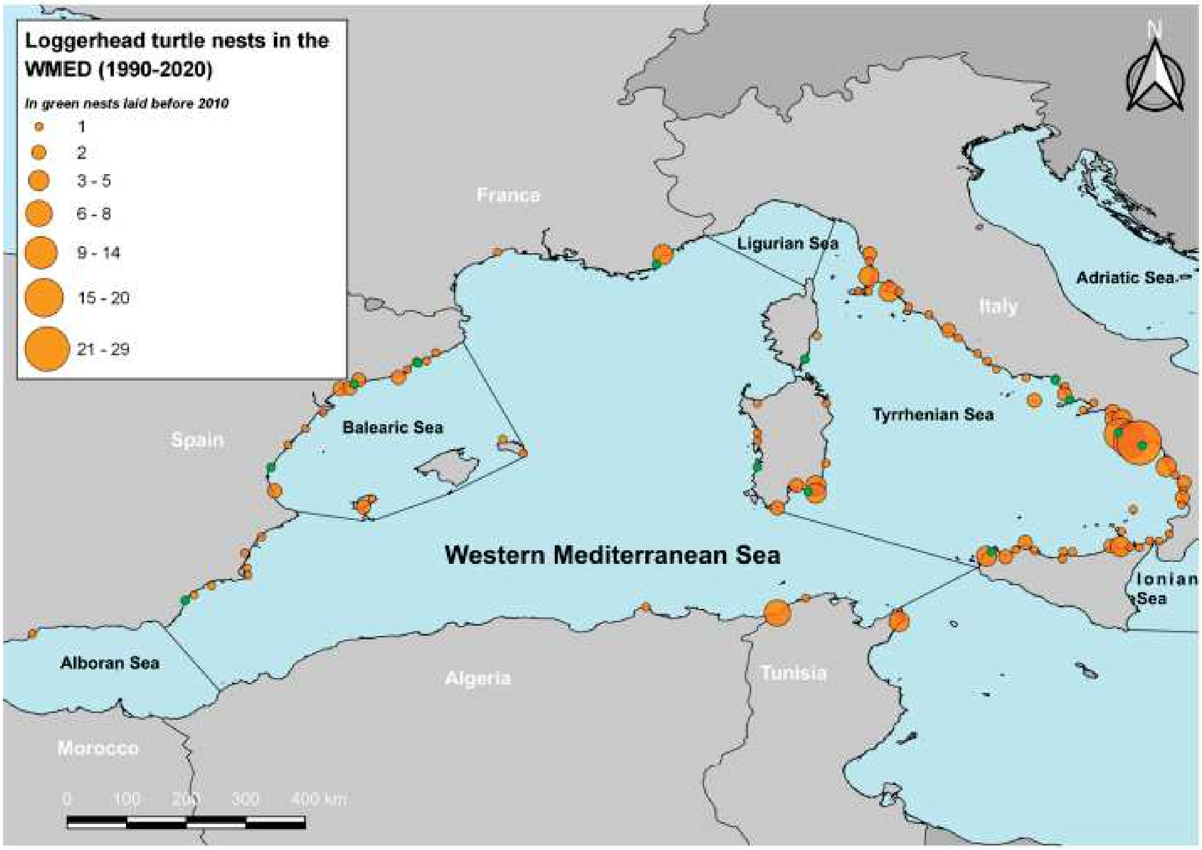


Fig. 4.3 [Distribution of loggerhead turtle nests in the Western Mediterranean; number of nests per 15 km., S. Hochscheid et al., 2022.]

The shift in the geographical nesting sites calls for an immediate identification of current threats posed to these species and a proposal of conservation actions that will permit these turtles to establish these new locations into stable nesting sites.

4.1.2 Italy and North Mediterranean

Italy is geographically positioned in between three distinct marine basins, i.e. Tyrrhenian sea, Ionian sea (with the strait of Sicily) and Adriatic sea. With the pelagic summer grounds of the loggerhead turtle in the first two sea basins mentioned, it is anticipated that sporadic nesting will occur along Italy’s coastline. Although sporadic nesting events have been recorded in the Adriatic sea, it remains a rare phenomenon. The basin serves as a foraging ground throughout the year, with sea turtles overwintering in its southern and eastern regions and dispersing across the entire Adriatic during summer months. Recent findings indicate an expansion of nesting into the Adriatic sea, where it was previously thought to serve only as a winter foraging ground (Pietroluongo et al., 2023) (see chapter 7.3).

Pietroluongo et al. (2023) documented the expansion of the loggerhead nesting activity on the Veneto coastline (northern Adriatic, Italy), reporting the two northernmost loggerhead nests in summer of 2021. These findings support their hypothesis that climate change is facilitating the northward expansion of Mediterranean nesting sites, potentially making the northern Adriatic a minor nesting area in the near future. However, nesting success in this region remains highly variable, with significant differences between sites due to human impact and environmental factors, with only 11% hatching success in the urbanised beach of Jesolo Lido in comparison to 89% success in the natural beach of Scano Boa. In Jesolo Lido, the nest was laid unusually close to the shoreline, primarily due to the high density of beach umbrellas and other anthropogenic obstacles, which led to high humidity in the nest and resulted in a fungal infection. This drastic contrast in the success rate highlights the negative impact of human activities and beach urbanisation, and most importantly in this case study, a fungal infection by the genus *Fusarium*, which significantly compromises hatchling survival. Studies as such help identify the need for enhanced monitoring and conservation strategies to assess the long term viability of these expanding nesting grounds and to address the threats posed by anthropogenic activities and emerging environmental challenges.

By 2023, the loggerhead turtle was documented nesting 23 times along the western coast of the Adriatic sea (Paterna, 2024). Most occurred in the region of Puglia, and two were located in Abruzzo. A significant nesting occurred in Borsacchio Nature Reserve in Teramo, Abruzzo, Italy and is considered as one of the northernmost successful nesting events recorded in the Adriatic region with an 86% survival rate. It was described as significant, since the hatchlings demonstrated asynchronous emergence. With hatchlings continuing to emerge up to 15 days after the first emergence, it was one of the longest asynchronous emergence events documented in literature (Paterna, 2024).

4.1.3 Libya

Libya hosts several nesting sites such as Al-Gbeba, Al-Arbaeen and Al-Netefia, along its 1,970 km coastline, out of which 1,144 km consists of sandy beaches (Laurent, 1995). Unlike other Mediterranean nations, Libya’s nesting beaches remain unprotected, which creates many conservational challenges. IUCN (2020) identified 12 significant nesting beaches in Libya that do not have any protective frameworks for nesting grounds put in place. This further increases chances for coastal development, human disturbance and predation.

First estimates by Laurent et al. (1995,1997,1999) suggested that Libya may have once hosted up to 9000 loggerhead nests annually, that could have been the largest loggerhead nesting population in the Mediterranean. However, subsequent studies of Camiñas et al. (2020), reported much lower numbers, with an average of 601 nests per year. Canbolat (2004) stated that these findings were inaccurate and called for further investigation. The drastic differences in these numbers suggests that either Laurent's previous estimates were overestimated (although said to be counted nest by nest, through crawl identification), or what more likely took place is habitat degradation and nest predation that led to a dramatic decline in the nest activity. In 1995 loggerhead predation by native animals in Libya was found to be a reoccurring issue (Laurent et al., 1995). Laurent's surveys on Libya's nesting sites were categorised in three phase assessment, which indicated that green turtles were rarely observed nesting in Libya. Hence, we can conclude that at the time, Libya took a role as a predominant loggerhead nesting region.

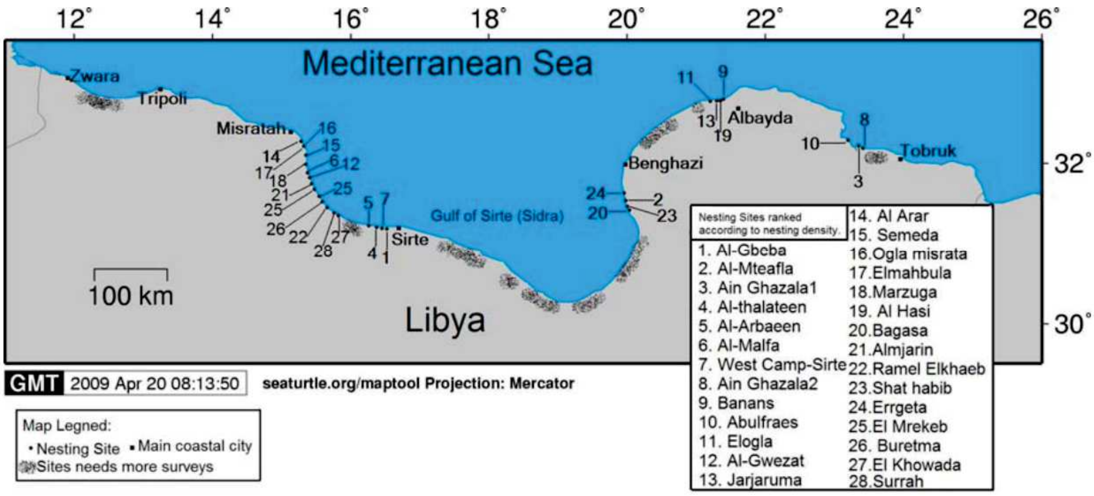


Fig. 4.4 [Loggerhead sea turtle nesting sites along the coast of Libya. Casale & Margaritoulis, (2010)]

It is crucial to point out the need for more accurate monitoring of the beaches along the Libyan coast, as information is still very scarce in the area. The sites that require more monitoring are shown in Fig. 4.4.

4.1.4 Cyprus

Cyprus hosts one of the few sites in the Mediterranean where both green and loggerhead turtles nest (Broderick et al., 2002). Cyprus can be divided into Region A (North) and Region B (South), and separate studies have been taking place since 1988 to establish active nesting sites for both the loggerhead and the green turtle. The north coast including Alagadi Beach and Morphou Bay are critical nesting sites for both species, in particular for the green turtle population.

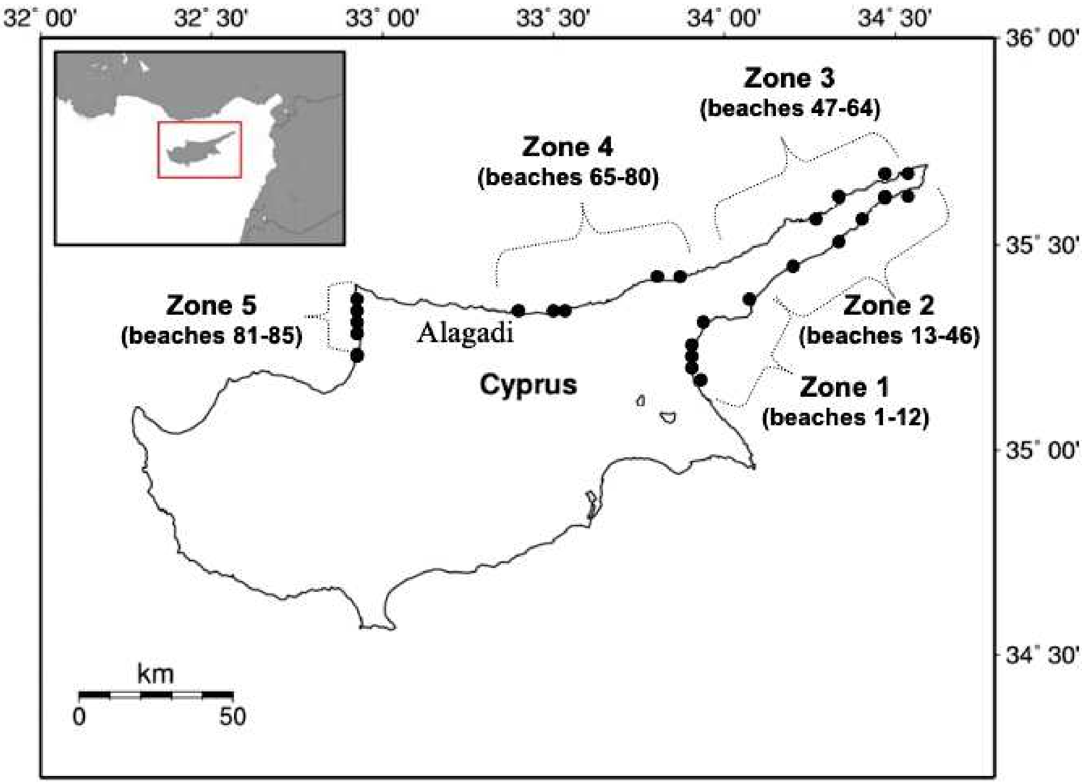


Fig. 4.5 [Loggerhead turtle nesting sites in Cyprus Region A since 1992, Beach numbers in parentheses are those found in Godley and Broderick (1992). Data from Zones 2 and 3 have been gathered by the responsible bodies for Environmental Protection since 1997, Casale & Margaritoulis, (2010)]

4.1.5 Tunisia

Loggerhead nesting in Tunisia has historically been low, with Groombridge (1990) and IUCN (2020) confirming minimal nesting activity. However the nesting is still present occasionally and this should be taken into account for future conservation strategies. A 2023 study by Jribi et al. surveyed 152 beaches along the Tunisian coast to identify previously undocumented nesting activity (Fig. 4.6). This research identified two regular nesting sites, Kuriat Islands and La Chebba. 16 beaches were identified with sporadic nesting sites and 11 showed signs of suspected activity. Out of all 152 beaches, only 20 beaches along the Tunisian coast are classified as unsuitable for nesting. This data suggests that Tunisian coast can potentially host nests under the scenario of the undergoing nesting pattern changes.

Fig. 4.6 [Sea turtle nesting sites identified in Tunisia; Jribi et al. (2023)]

4.2 Green turtle (*Chelonia mydas*) nesting sites

Nesting of the green turtles is much more localized than that of the loggerhead, with most of nesting occurring in the most Eastern part of the basin, i.e. Turkey, Cyprus (Broderick et al., 2002) and Syria (Casale & Margaritoulis, 2010). The Turkish coastline is the most important nesting area for the green turtle (Canbolat, 2004). According to Kasparek's (2013) findings, 99% of all recorded nesting occurs in Cyprus and in Turkey, with the remaining found in Lebanon, Israel and Egypt with 78% of all nests concentrated at five key sites, three of them in Turkey (Akyatan, Kazanlı, Samandağ) and two in northern Cyprus (North Karpaz, Alagadi). IUCN (2020) provided a list of thirteen major nesting sites out of which six are in Turkey (three of them are the most abundant in terms of average nests/year), six in Cyprus and one in Syria (Annex; Figure B).

4.2.1 Major Nesting Sites

In a more recent study by Snape et al., (2022), the population of green turtles on Cyprus coastline has been observed to be increasing over the past years. An increase of 198% since 1993 on the island and an increase of 307% at Alagadi beach in particular. This is all purely due to the conservation strategies that have been implemented and followed throughout the period (Snape et al., 2022). This acts as direct evidence that if conservation efforts are met, the population will increase. By tracking female green turtles, it was established that out of thirteen major green turtle nesting sites, five of them are along the Cyprus coast (Snape et al., 2022). Presence of Specially Protected Areas (SPAs) has shown to contribute to the increase of clutch sizes over time (Snape et al., 2022). Conservation work in Cyprus began in early 1990s and if not for the efforts of SPAs, the nesting sites could have been easily impacted by coastal development.

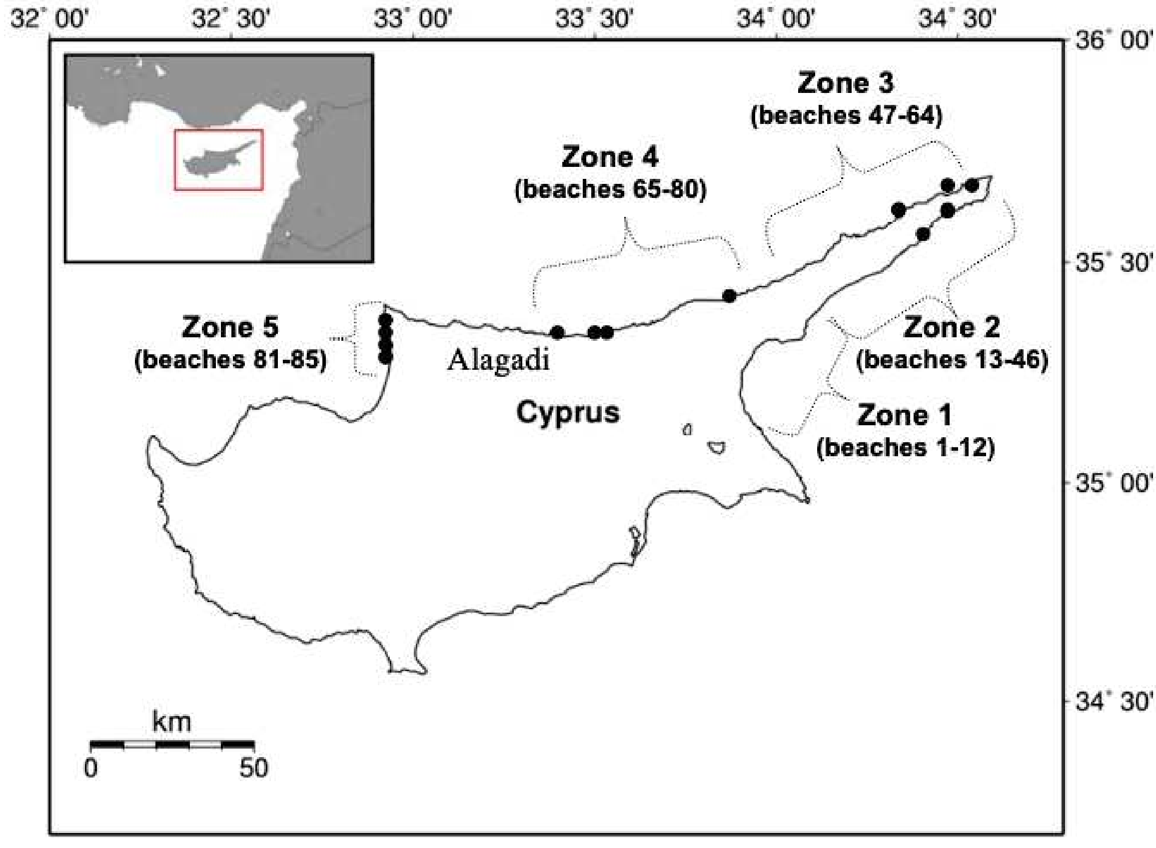


Fig. 4.7 [Green turtle nesting sites in Cyprus Region A since 1992, Beach numbers in parentheses are those found in Godley and Broderick (1992). Data from Zones 2 and 3 have been gathered by the responsible bodies for Environmental Protection since 1997, Casale & Margaritoulis, (2010)]

In Turkey, Canbolat (2004) identified Kazanli (24.1%) and Akyatan (54.4%) as the green turtle major nesting sites (Canbolat, 2004). The shifts in nesting sites preferences are observed if studies conducted in 1984 are taken into account. Geldiay (1984) established the Mersin, Tuzla, Karatas and Yumurtalik regions as important nesting grounds for the green turtle (Baran and Kasperek, 1989). Today, Kazanli, Akyatan and Samandag are the three major sites for the green turtle (Fig. 4.1).

4.2.2 Western Mediterranean

While stranding and foraging events have been observed in Italy, no nesting activity has been observed until recently. Occasional sightings without nesting have been reported in France, Spain and Morocco. In 2019 an exceptional nesting event of a green turtle was recorded in the Kuriat islands, Tunisia. That represented the most western record of the green turtle (Ben Ismail et al., 2022) and can be observed in Fig. 4.6.

It is true to admit that to evaluate the status of population of these species, studies mostly have to rely on annual nest counts. Canbolat (2004) speculated on the estimate issue and concluded that the wide estimates clearly demonstrate the need for much more data on this aspect. As even a slight change of 1 nest/year can shift the overall numbers drastically, making the findings inaccurate and misleading. Hence, if the estimation is based on the clutch sizes in known nesting sites, with the change of breeding sites, new studies have to be conducted to evaluate hatching success and new assessments have to be performed to evaluate suitability of nesting sites. As the nesting sites shift, the previously used data can not be a true representation of the population status.

5. Legislation in Mediterranean

Successful conservation of the loggerhead turtle and green turtle in the Mediterranean is a contribution of many factors that include international conventions, agreements and regional legislative frameworks. Quite a few of the International conventions and agreements protect marine turtles in the Mediterranean by regulating trade, enforcing conservation measures, promoting habitat protection and monitoring population trends.

5.1 International Conventions

Both the loggerhead turtle and green turtle are listed in Appendix 1 of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which prohibits any international trade of these species among contracting parties. Since 1975, all marine turtles have been included under the protection category (CITES, 2022). With the only exception of African softshell turtles, which are listed under Appendix II (Camiñas et al., 2020), since they are not threatened by extinction but may become if the trade is not controlled. By implementing these protection measures and restricting international trade, CITES aims to prevent the exploitation of marine turtles for their meat, shells and eggs. This does not take into account further illegal trade that took place before and after the agreement was put in place.

The Barcelona Convention (Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean, SPA/BD protocol) provides a framework concerning specially protected areas and biological diversity in the Mediterranean. Both the species are listed in the Annex II of the protocol, which mandates strict protection measures for these species. In 1989, the Barcelona Convention developed and introduced an Action Plan specifically for the conservation of marine turtles in the Mediterranean. The framework was later on updated in 1999 and 2007. This plan requires all Mediterranean countries to report on conservation efforts every two years.

The Convention on the Conservation of European Wildlife and Natural Habitat (Bern Convention, 1979) lists five marine turtle species, including the loggerhead turtle and green turtle, under Appendix II. This classifies them as strictly protected fauna species, requiring countries involved in the convention to prohibit deliberate capture, killing or disturbance of these species and enforces the protection of the breeding and nesting sites as habitat conservation measures (Camiñas et al., 2020; Casale & Margaritoulis, 2010).

The Convention on the Conservation of Migratory Species of Wild Animals (CMS, Bonn Convention, 1979) includes both the loggerhead turtle and green turtle out of the five marine turtle species in Appendices I & II (Camiñas et al., 2020). The Convention on Biological Diversity (CBD) is as well involved in the maintenance of viable populations of species and promotes recovery of threatened species.

5.2 EU Legislations

The aim of the European Union Habitat Directive is to protect, manage and restore conservation status. The Habitat Directive lists both the loggerhead turtle and green turtle species in Annexes II and IV. Annex II identifies the marine turtles as priority species, and requires the designation of Special Areas of Conservation (SACs) for habitat protection, in this Annex only the loggerhead turtle and green turtle are listed out of all seven marine turtle species. Annex IV recognises five sea turtle species of community interest in need of strict protection.

5.3 Regional Legislations

The African Convention On The Conservation Of Nature And Natural Resources provides additional protection for marine turtles along the African Mediterranean coasts of Algeria, Libya, Morocco, Tunisia and other countries that are not discussed in this dissertation. Listed under Class A in the treaty that states “species in Class A shall be totally protected throughout the entire territory of the Contracting States; the hunting, killing, capture or collection of specimens shall be permitted only on the authorisation in each case of the highest competent authority and only if required in the national interest or for scientific purposes”. Treaty was signed on the 15th of September 1968, entered into force the following year 1969 and registered with the United Nations on 31 March 1975 (Organization of African Unity, 1968).

5.4 Non-Governmental Conservation

Beyond government led legislation, international organisations have been advocating for marine turtle conservation. The World Wide Fund for Nature (WWF) developed an Action Plan in 2005, which was expanded into a Global Marine Turtle Strategy (WWF, 2009). This 44 page document outlines WWF’s conservation priorities, considering both species specific needs and broader ecosystem protection measures. WWF claims to be actively involved in nesting site protection, bycatch reduction, and public awareness campaigns.

The legal protection of the loggerhead turtle and green turtle in the Mediterranean is well established at an international level, with multiple conventions, agreements and EU directives. Despite legislative frameworks providing a strong theoretical protection for marine turtles, the effectiveness of it all purely depends on national enforcement, monitoring and compliance. The success of the legal frameworks depends on combined efforts of all the stakeholders involved. Furthermore, these species face threats that are not under the control of the government and law enforcement, such as climate change and habitat shifts.

To understand what conservation strategies are required to reduce mortality of hatchlings and promote increase in nesting activity in adult females, it is first important to identify the location of nesting sites and then the threats posed to these marine animals, which can be location specific, and can be influenced by the presence of legislation frameworks put in place in these individual areas, in case of predation and poaching. So far, previous and emerging nesting sites have been identified and change in average nesting per year has been noted, as well as legislative frameworks and regulations that are active in the Mediterranean basin. On these coastal sites, sea turtles face many dangers, both natural and man made (anthropogenic), which are also contributing factors to these migratory changes and can result in localised extinctions. Threats accumulate over long periods of time and can occur anywhere in a population's range (Choi & Eckert, 2009).

6. Anthropogenic Threats

Anthropogenic means “man made”. One of the major threats to sea turtles caused by men at sea is fishing bycatch. Although mostly accidental, this may lead to death in mature female loggerhead and green turtles before they reach the shore to nest. Marine traffic, fisheries, and plastic pollution are major contributors to strandings and injuries. Along the south Tyrrhenian coast (western mediterranean), Serra et al. (2023) found 60% of turtles showing anthropogenic injuries, including collisions with boats that resulted in carapace fracture, along another leading cause of mortality being fishing gear entanglement. Another 38.5% was found with ingested marine debris, such as hooks and lines that resulted in intestinal damage and sometimes death (Serra et al., 2023). Degradation of reproductive habitat (Casale et al., 2014) further contributes to the list of major anthropogenic threats that directly affect the mortality of clutches and population dynamics.

6.1 Coastal Development

The Mediterranean coastline is the number one tourist destination in the world, with 360 million visitors annually. Construction projects near or along beach coastlines to support the high tourism pose a significant threat to sea turtle Mediterranean populations. Urbanisation and infrastructure projects such as hotels, resorts, roads etc. along the coastlines, disrupt critical nesting habitats and can result in a net reduction in beach area, a phenomenon known as “coastal squeeze”, which in turn limits the available habitat for marine turtle populations (Biddiscombe et al., 2020). All this can be described as habitat destruction. All nesting sea turtle species prefer to select an obstacle-free sandy beach for nesting. Coastal development is not just construction of buildings, but also exploitation of sandy beaches by touristic infrastructures, including beach umbrellas, sunbeds, lighting systems, all of which can disrupt nesting behaviour and increase hatchling disorientation. Removal of natural vegetation, sand mining, obstructions and driving vehicles on the beach are all contributing to threaten sea turtle survival and possibility to nest. Green turtles in particular, tend to nest further away from the water line, and in comparison to the loggerhead, green turtles dig a deeper nest, making them more vulnerable on the nesting beaches with high level of coastal development.

Study by Biddiscombe (2020) provided a global assessment of anthropogenic development along marine turtle nesting beaches. Using Google Earth satellite imagery to quantify hard anthropogenic coastal development (HACD), study concluded that coastal squeeze combined with rising sea levels along coastal beaches with HACD, will threaten nesting habitat. This needs to be addressed as in the upcoming century, the global sea level is expected to rise between 0.23 to 0.82 meters (Biddiscombe et al., 2020). The Mediterranean has been identified as one of the most highly urbanised marine turtle nesting beaches, with 40% of surveyed beaches classified as highly developed. (Biddiscombe et al., 2020). Coastal urbanisation, particularly in Southern Italy, Turkey, Egypt, and Lebanon, significantly reduces the availability of undisturbed nesting habitats. Conversely, in other regions, such as Australia and Africa, over 75% of nesting beaches remain undeveloped, and are classified as low anthropogenic coastal development (LACD). Conservation efforts should prioritise the protection of remaining low anthropogenic coastal development regions to reduce the risk of further habitat loss. The loggerhead is particularly vulnerable, as identified by Biddiscombe (2020), 38% of its global nesting range is backed by hard anthropogenic structures.

The type of sand does not significantly influence sea turtles selection of nesting sites (Patiño-Martínez et al., 2022). Instead, factors such as urbanisation and coastal development have a greater impact on nesting ground choice, often deterring females from otherwise suitable areas due to light pollution, human activity, and habitat degradation (Casale, 2010). In fact, sea turtles must compete for their nests with tourists and coastal residents, being often forced to use suboptimal nesting habitats or even to waste their eggs in the sea (Witherington and Martin, 2003). Construction sites contribute to light pollution, the next anthropogenic threat discussed in this thesis.

6.2 Light

Light pollution is a persistent and growing challenge in coastal areas worldwide, significantly impacting sea turtle behavior and nesting success. It is defined as the artificial introduction of light into environments where it is neither necessary nor ecologically appropriate. Both adult and hatchling sea turtles are highly sensitive to artificial lighting, which can deter nesting females from coming ashore and lead to disorientation in hatchlings (Choi & Eckert, 2009). Under natural conditions, hatchlings instinctively orient toward the brightest natural light source, the horizon over the ocean. However, in the presence of artificial lighting from coastal developments, hatchlings may become misdirected or disoriented, unable to follow a consistent path to the sea (Choi & Eckert, 2009). This drastically increases their vulnerability to predation, dehydration, and exhaustion, further reducing survival rates (Witherington & Bjorndal, 1991). Witherington and Bjorndal (1991) studies have shown that even low levels of artificial light can cause the species to disorient.

Beyond the direct beachfront lighting, indirect sources such as illuminated buildings (hotels and residential buildings), street and road lights contribute to the pollution and both have an impact on the nesting beaches even from several kilometers away. The light and “sky glow” disrupts natural darkness levels which interferes with the nocturnal nesting behaviours of the sea turtles and reduces the effectiveness of conservation efforts aimed at light management (Choi & Eckert, 2009). Beach shores located close to a city might show lower nesting attempts.

6.3 Poaching

Poaching remains a significant anthropogenic threat to sea turtles in some parts of the Mediterranean, driven by both cultural tradition and economic benefits. Sea turtles have been exploited for their meat and eggs for centuries, looked as a valuable source of nutrition, income for poachers and medicinal properties in various coastal communities. Beyond consumption, sea turtles are exploited for products such as oil, leather and shell products all around the world (Choi & Eckert, 2009).

Intense exploitation of sea turtles for food and international trade occurred previously in the Mediterranean, particularly in the Levantine Basin (Casale, 2018). In some areas, turtle poaching is deeply rooted in cultural traditions. For example, among the Mareremi people of Kenya, turtle meat is believed to strengthen children, leading to targeted hunting of turtles for pregnant women (Akani et al., 2023). Poaching methods to hunt these species range from tracking females before they lay eggs to the use of longlines, nets, harpoons, and underwater spears in foraging grounds. In some areas, sea turtle eggs were believed to have an aphrodisiac and medicinal effect, increasing their demand and contributing to the population decline in those areas (Casale & Margaritoulis, 2010; Akani et al., 2023). In Nigeria's Andoni culture, according to Akani et al., (2023) turtle shells are even used to summon emergency meetings. Very weak law enforcement, corruption, lack of funding and absence of beach petrol makes it extremely difficult to eliminate this anthropogenic threat in those areas. In the Mediterranean area, egg consumption is rarely documented in Libya and egg sale have been noted in Zwana, Misurata and Sirte (Casale et al., 2021). Human exploitation of eggs and meat has been documented previously, fishermen sharing that international boats along the western coast of Mediterranean would indulge in such so-called delicacy. Information can also be found on the public's opinion on the taste of meat of each individual turtle, with fishermen stating that the leatherback's meat is "not as good as the other two" (Casale & Margaritoulis, 2010). Previously in Egypt consumption of sea turtle blood has been observed by women as they believed it would help them gain weight.

A multi-layered survey was conducted in the past along the Egyptian coast to identify if there is a correlation between the level of education and sea turtle meat consumption. Three groups were taken into account, the fishermen in the fishmarket of Anfoushi, the general public who were illiterate or have not completed their primary education and the educated general public. Findings supported their theory that education plays an important role in reducing turtle meat consumption, as, when asked if the groups craved to consume sea turtle meat, 81.3% of fishermen, 39.7% of the uneducated public and 6% of educated public stated "Yes".

Although CITES entirely prohibits any legal trade or exploitation of marine turtles for their meat, shells and eggs in the EU, parts of the world such as Ostional in Costa Rica allow for more localised strategies. Instead of entirely banning the trade, it is highly regulated and tracked in the Caribbean waters (Pheasey et al., 2025). Although economically beneficial to local communities, it has shown its own difficulties; high competition from the illegal trade market and unequal profit distribution that benefits the monopolised market more than the local communities. Genetic tracking of seized turtle products is a possible strategy to identify the origin of poaching, but can be looked at as a threat towards the local communities.

7. Natural Threats

Sea turtles come across many natural threats throughout their life cycle, ranging from predation (ex. Libya) and extreme weather events to habitat instability and parasite/disease outbreaks. While anthropogenic activities pose significant danger to the populations of these marine turtles, natural factors are also crucial in their reproductive success. Hatchlings are the most vulnerable, with low survival rates (0.1% survival rate) due to predation by birds, crabs, fish, and even dogs. Adults are facing harsh conditions too, with climate change influencing their migratory, foraging and nesting behaviours. Meanwhile also mining ecological equilibrium that turtles have built with natural threats for millions of years.

7.1 Parasites and Diseases

While conservation efforts primarily address anthropogenic threats such as habitat destruction, climate change, and bycatch, infectious diseases pose a significant risk to loggerhead and green turtles. These threats range from parasitic infections to viral, bacterial, protozoan, and fungal pathogens which can impact both adult turtles and unhatched eggs. The effect of parasites and diseases on adult sea turtles is elaborated more in the following chapter "Natural threats to adult, reproductive stage sea turtles". Pathogens may invade nests, lowering the hatching probability (Choi & Eckter, 2009; Pietroluongo, 2023)

In recent years, a newly emerging and globally concerning disease affecting sea turtle populations is Sea Turtle Egg Fusariosis (STEF) primarily caused by two pathogenic fungi from the *Fusarium solani* species complex: *Fusarium falciforme* and *Fusarium keratoplasticum* have been identified (Gleason et al., 2020). These fungi have been detected across all seven sea turtle species and are associated with significant hatch failures due to their colonisation of nesting environments and direct infection of eggs. The pathogens are believed to originate in terrestrial soils, transported to beaches through ocean currents, often attached to organic debris or microplastics. Once in turtle nests, the fungi proliferate under warm, moist conditions, degrading eggshells and embryonic tissues via enzymatic activity and potential mycotoxin production (Sarmiento-Ramirez et al., 2014). The northernmost case of a nesting event that had occurred in the Adriatic sea was a clutch that was affected by genus *Fusarium* (Pietroluongo et al., 2021). Infection can spread rapidly within a clutch and can be influenced by microclimatic conditions, organic matter accumulation and possible immunosuppression in embryos due to environmental contaminants.

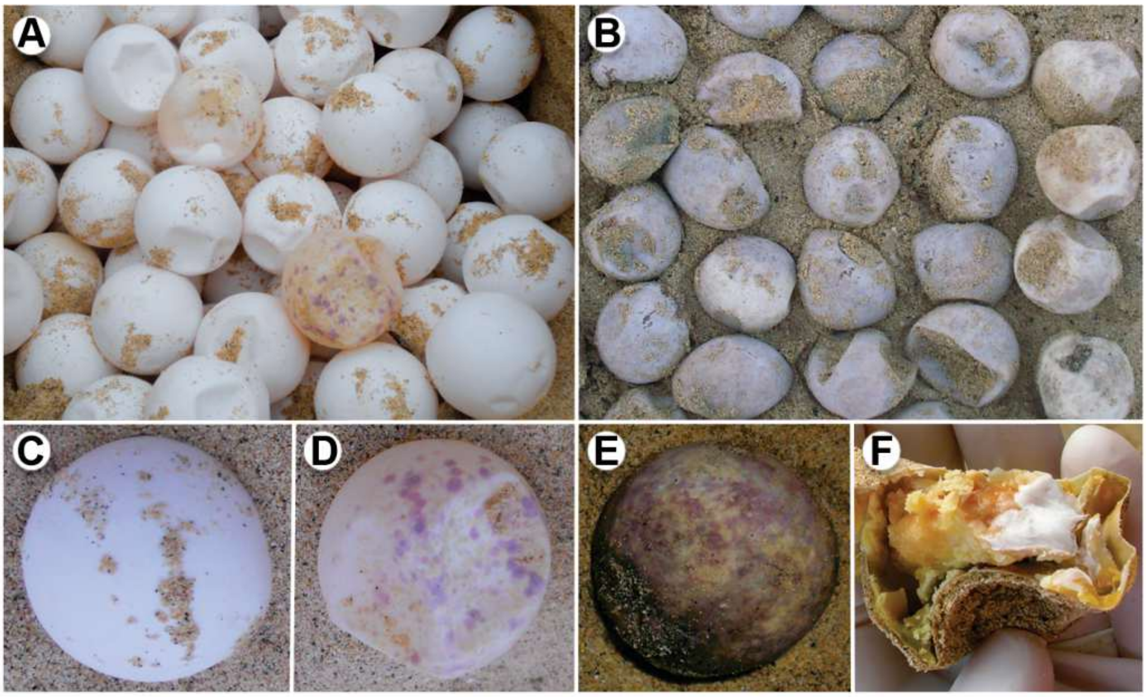


Fig. 7.0 [Nests of the sea turtle species Caretta caretta affected by Fusarium at different stages of incubation. (A) Nest at initial stage of incubation (two weeks) showing an egg with characteristic signs of Fusarium infection (yellowish, reddish and bluish spots). (B) Nest at final stage of incubation (eight weeks) with all eggs with advanced signs of Fusarium infection. (C–D) Eggs at early stage of incubation. (C) Healthy asymptomatic egg. (D) Symptomatic egg. (E–F) Eggs at late stage of incubation. E) Egg with severe signs of Fusarium disease. F) Dead embryo on Fusarium infection with white mycelia inside the egg; Sarmiento-Ramirez et al., 2014)]

The pathogenesis of egg Fusariosis begins when fungi is present in the surrounding sand and comes into contact with the eggshell. Once the contact occurs, the fungi colonise the eggshell and gain access to the internal egg contents. First the mycelial penetration of the shell and membranes takes place, compromising the protective barrier and facilitating access to embryonic tissues, followed by the disruption of gas exchange. Then the production of mycotoxins and secondary metabolites directly damages the embryonic cells (Sarmiento-Ramirez et al., 2014). The fungi depleted the egg from nutrients by utilising the egg contents for its own growth. The development and spread of this fungus is heavily influenced by environmental conditions that create ideal conditions for fungal growth and infection. Key contributors include tidal inundation and high clay or silt content in nest substrates, both of which hinder gas exchange and increase moisture. Nests located in low-lying beach areas subject to seawater flooding show significantly higher rates of Fusarium infection and embryo mortality. Additionally, the optimal growth temperature of *Fusarium* species aligns closely with sea turtle egg incubation temperatures, further facilitating fungal proliferation. Organic matter from dead eggs can act as reservoirs for infection, promoting spread within the nest. Lastly, inadequate nest relocation practices and poor hygiene in hatcheries can exacerbate disease outbreaks. (Sarmiento-Ramirez et al., 2014). Anthropogenic elements that alter the beach's natural structure may increase the number of nests invaded by *Fusarium*, as also do the climate change-driven beach floodings or phenomenon of beach erosion.

7.2 Predation

Predator - prey interactions are critical in shaping population and ecosystem dynamics. Sea turtles body size increases as they grow with age, and the chances of becoming prey decrease, but are not zero. Eggs, hatchlings and small juveniles face the highest amount of danger. Various studies (Baran & Kasparek, 1989, Casale & Margaritoulis, 2010) confirm widespread nest predation. Natural predators, those already inhabiting the nesting beaches, such as ants and crabs also prey on newly hatched sea turtles. Other natural predators that are less studied are monk seals (*Monachus monachus*). Monk seals are opportunistic predators that mainly consume fish, cephalopods, mollusks, and crustaceans. A study along the Turkish coastline documented two cases of monk seal predation on green sea turtles, providing the first direct visual evidence of this interaction (Kıraç & Türkozan, 2023). In 2018, a stranded female monk seal in Mersin (Turkey) was found with a green turtle's fore flipper lodged in its mouth and an additional turtle bone stuck in its throat, indicating a failed predation attempt. In 2021, a juvenile monk seal was recorded attacking a juvenile green turtle in Antalya, tossing it around for approximately an hour before ultimately killing it. Similar predation patterns were previously observed in Zakynthos island (major nesting site), Greece, where 21 loggerhead turtles were found stranded with injuries attributed to monk seal attacks (Margaritoulis & Touliatou, 2011).

Litter is a major contribution to this already active threat. Litter may entangle or trap emerging hatchlings, preventing them from reaching the sea. The smell of garbage, however, is an attraction to non - native predators. Dogs and rats may arrive for the smell and eat entangled hatchlings (Choi & Eckert, 2009).

In 1995 on the coasts of Libya, researchers mentioned briefly the level of predation present on the beaches was high (Laurent et al., 1995). It was only mentioned briefly, however recent studies show a drastic decline in average nest/year. Predation could have been a confounding factor to the population decline. Same year, Brown and Macdonald (1995) assessed factors affecting nesting success at Akyatan beach (one of the three major nesting sites of the green turtle in Turkey), and found that 75% of nests were preyed on by red foxes (*Vulpes vulpes*) or golden jackals (*Canis aureus*). The study also found that predation occurred systematically, with canids using turtle tracks as cues to locate nests, and in some cases, defecating near nests on the night of the attack, potentially marking them as food sources for future visits.

Possible solution to the threat is to provide a physical barrier on the incubating nests and removing barriers at time of hatchling. This requires a particular effort by the community, and will be furtherly discussed in the next chapter (see chapter 8.2.2).

7.3 Climate change

Climate change poses a growing threat to populations of sea turtles and hatchlings in the Mediterranean. The effect of climate change is expressed as global warming (Simantiris, 2024), sea-level rise (Fish et al., 2008), extreme storms, and alterations in predation and diseases' patterns (Simantiris, 2024). These impacts extend across every habitat sea turtles depend on, from beaches to foraging areas.

One of the most major impacts of climate change is sea level rise, which contributes to coastal erosion and flooding of nests on the beaches (Fish et al.,2008). The coastal erosion reduces the availability of suitable nesting habitats and leads to flooding, ultimately resulting in embryo mortality and reduced hatching success (Pike, 2014).

Another major impact of climate change is the alteration of sand temperatures, which affects both of these species that express temperature-dependent sex determination (TDS). Rising sand temperatures skew hatchling sex ratios heavily toward females, potentially leading to future cases of reduced genetic diversity (Hawkes et al., 2009). Moreover, extreme heat may exceed the thermal tolerance for embryonic development, which will result in lower hatching success or complete nest failure (Pike, 2014). In addition to nesting impacts, climate change is expected to change ocean currents (Simantiris, 2024) that are critical for hatchlings during their early years of life. This factor influences the distribution and accessibility of food resources and can affect foraging patterns as well. Climate change, through the alteration of water temperatures, ocean acidification, as well as rainfall and storm patterns, influences the dynamics of marine diseases, which can affect sea turtles (Tracy et al., 2019), such as fibropapillomatosis that has been linked to climate related stressors.

With climate change, there is also expected expansion of nesting activity into previously unoccupied areas. A species distribution modelling study by Mancino et al. (2022) revealed the center of gravity for all nesting grounds had shifted roughly 1300 km to the northwest. For the past six decades the loggerhead turtle has been migrating from traditionally documented nesting grounds such as Greece, Turkey and Cyprus, towards the western Mediterranean coasts, including Italy, France and Spain (Hochscheid et al., 2022). Nesting suitability in these new areas is correlated with optimal sea surface temperatures between 24 - 25° C, above or below which the nesting success declines.

Similarly, for green turtles, Mancino et al. (2023) projected that up to 67% of Mediterranean coastlines could become climatically suitable for nesting by 2100. Different from what is found in most global change studies, the worse the climate change scenario, the more suitable areas for green turtles will potentially arise (Mancino et al., 2023). While this may look like a success against habitat loss in eastern sites, it introduces new challenges. Emerging nesting areas, particularly in the western Mediterranean, are heavily pressured by tourism and infrastructure. While climate change may open new possibilities for nesting range expansion, it simultaneously calls for urgent actions for habitat protection in these regions.

7.4 Natural Threats to Adult, Reproductive Stage Sea Turtles

Sea turtles host a variety of epibiotic organisms, ranging from mutualistic to parasitic. Loggerhead shells commonly support large epibiont communities, including barnacles (*Platylepas hexastylos*, *Chelonibia testudinaria*). While barnacle colonisation is typical for healthy turtles, excessive growth on sensitive areas, such as the eyes or mouth, can affect self-grooming and feeding, and will increase energy expenditure and infection risk (Stacy et al., 2018).

Marchiori (2023) identified another ectoparasite in the north Mediterranean, copepod *Balaenophilus manatorum*, a true ectoparasite, feeding on keratin from the skin of loggerhead turtles, particularly on the neck and flippers, leading to erosive to ulcerative lesions. Turtles suffering from Debilitated Turtle Syndrome (DTS), a condition characterized by emaciation, lethargy, and heavy barnacle coverage (Stacy et al., 2018), are more prone to infestation (Marchiori et al., 2023). There is no specific identified cause that leads to chronic debilitation in marine turtles, the current hypothesis is that this condition is consistent with the end stage of starvation and any cause preventing nutrient uptake or absorption can lead to this state (Stacy et al., 2018).

Marine turtles and in particular the loggerheads also host endoparasites, including almost the most pathogenic the cardiovascular flukes of the family *Spirorchiidae,* and the gastrointestinal nematode *Sulcascaris sulcata* (Alfaro, 2006), which can cause severe illness in turtles infected with high parasitic burden.

Research along the Tuscany coast also detected *Betanodavirus* in loggerhead turtles*,* a pathogen primarily known for causing viral nervous necrosis (VNN) in fish species (Shetty et al., 2012), though no pathogenic effect was observed, it raised concern. Several Gram-negative and Gram-positive bacteria contribute to systemic infections in sea turtles. Notable species include *Pseudomonas fluorescens*, *Vibrio alginolyticus*, *Aeromonas hydrophila*, and *Salmonella regent*, which can cause septicemia, and gastrointestinal diseases (Alfaro, 2006). In Tuscany, sea turtles were identified as carriers of *Lactococcus garviae* bacteria, another fish pathogen responsible for hyperacute hemorrhagic septicemia (Fichi et al., 2015).

Fungal infections, primarily caused by *Fusarium solani*, *Aspergillus sp.*, and *Colletotrichum acutatum*, have been identified in both captive and wild turtles (Alfaro, 2006), often affecting the shell and seldomly spreading to systemic infections. Additionally, protozoa such as *Caryospora cheloniae* have been detected, even though not in the Mediterranean Sea, responsible for lethal infections in green turtles (Alfaro, 2006).

The loggerhead and the green turtle both face many threats throughout their life cycle, starting from the moment they are laid in the egg, all the way throughout their mature life. The one's mentioned in this thesis have been identified as the ones of most concern at this moment. Further, the public engagement projects will be broken down, following the existing conservation strategies that are put in place to maintain the increase in population trends.

8. Conservation Strategies

In favour of the sea turtles, this topic of animal conservation is openly discussed and revisited, with new legislations and protective measures arising annually. In comparison to other species inhabiting the marine waters, these animals have the support of the researchers as well as continuous efforts of the public. Sea turtle has become the mascot of plastic reduction campaigns such as plastic straws. Effective conservation strategies often involve integration of research, legislation, public education and habitat protection. For instance, manuals with step by step instructions exist for handling sea turtles to guide both the general public and the fishermen how to handle accidentally captured sea turtles, including safe release techniques and contact information for rescue centres. As mentioned previously, informative leaflets in hotel rooms and at hotel receptions have already started appearing and this acts as a step towards starting a conversation with the tourists.

8.1 Mitigating Anthropogenic Threats

The protection of individual nesting beaches is critical for the survival of distinct sea turtle populations, as female sea turtles exhibit strong natal homing behaviour, returning only to those beaches where they hatched themselves, to lay their eggs. This means that each individual beach supports a demographically independent stock of sea turtles, and a loss of a single nesting site could collapse an entire subpopulation. Therefore, conservation strategies must prioritise protection of each nesting site as a unique and irreplaceable habitat unit (Demetropoulos, 2009).

Establishing marine protected areas (MPAs) in the Mediterranean requires an approach that includes both terrestrial and marine habitats, both for hatchlings and nesting females. These areas should take into account the terrestrial area right above the beach, to mitigate threats such as light pollution, as well as the adjacent waters to a depth of at least 20 meters, which are used by turtles during inter-nesting intervals. It can be unnecessary to declare a protected area the total length of beaches where low numbers of nests are observed. Instead, restrictions should focus on the densest nesting zones, with seasonal restrictions between May and October, which prohibit beach access at night, driving on the beach and restricting fishing activities, are essential steps to safeguard sea turtles nesting and hatching (Demetropoulos, 2009). This approach has successfully been adopted in Israel and Egypt (Casale & Margaritoulis, 2010, Snape et al., 2022). Key nesting beaches in Egypt (Alagazi, Karpaz) have shown strong population recovery on beaches with an established Specially Protected Areas (SPAs) network (Snape et al., 2022).

8.1.1 Coastal Development and Set Back Regulations

Set back regulations were introduced to prohibit construction within a set distance from the sea and have the potential to mitigate loss of beach area by providing a "buffer zone" (Fish et al., 2008). Enforcing seasonal restrictions that can limit construction during peak nesting and hatching season can be a good conservation strategy, however enforcing and actually regulating the restrictions is very different. Unfortunately, the nesting season occurs during the busiest tourism season annually, and complete elimination of these activities throughout the whole Mediterranean basin is simply unrealistic. Restricting the construction may lead to losses of seasonal jobs. Instead, focus should be allocated to further educating the public and the hotel industry on measures that can contribute to both the sea turtles and to the tourism industry. For example, implementing only night restrictions and engaging the public about the presence of nesting turtles can be a good start to a successful conservation strategy. Nest relocation can take place if beaches experience high human presence (see chapter 8.3).

8.1.2 Tourism and Human Disturbance

Evidence demonstrates that coexisting human activities and sea turtle conservation strategies can be effectively balanced, as seen in Zakynthos, Greece. In Laganas Bay (Annex, Figure A), one of the most important nesting grounds for loggerhead sea turtles in the Mediterranean, strict spatial and temporal regulations permit shared use of the beach. Public access is prohibited at night to avoid disrupting nesting or hatchling emergence, and beach furniture is removed nightly to ensure nesting without obstruction. Information posters, protective nest cages and on site ARCHELON volunteers contribute to public awareness. Visitors are advised to limit their activities within the first 5 meters of the beach from the sealine, to avoid touching hatchlings and follow respectful conduct during turtle boat tours. Although this can be debated as human presence may disturb the sea turtles, this showcases that shared spaces are possible between the endangered species and the general public. The same can be stated for nesting beaches in different regions. For example, Isola di Lampedusa in Italy (Prazzi et al., 2013), and other major nesting beaches in Turkey, Egypt, and Cyprus (Casale & Margaritoulis, 2010) have shown that long-term conservation measures targeting the tourism industry by controlling tourist access and establishing night petrol can mitigate this anthropogenic threat.

8.1.3 Light Pollution Management

While light pollution is a major anthropogenic threat, it is also one of the most manageable conservation challenges. Hotels, resorts, and coastal developments can implement solutions such as using turtle-friendly lighting, shielding lights to minimize sky glow, and adopting seasonal adjustments to reduce illumination intensity during peak nesting periods (Choi & Eckert, 2009). Light pollution poses a threat primarily during the nesting season. Conducting systematic inspections of nesting beaches, particularly in areas where sporadic nesting events are becoming more frequent and may require enhanced protective measures, can be an effective conservation strategy. Many solutions have been proposed to manage this threat;

1. Conducting regular day and night annual lighting inspections in hotels/resorts to keep identifying problematic light sources before the nesting season begins. Assigning individuals to conduct these checks can create jobs in the conservation field.
2. After annual assessments, removing unnecessary lights that do not serve any purpose.
3. Using low impact lighting such as low pressure sodium vapour lamps or red/amber LED lights instead of bright white lights such as metal hyalites and high pressure sodium vapour lights as they affect the sea turtle (Choi & Eckter, 2009). This investment into low wavelength light will further reduce unsuccessful nesting attempts.
4. All external lights should be shielded and directed downward, also away from the nesting beach.
5. Lowering the height of the lights towards the ground will minimise the visibility from the beach, further reducing the possibility of disorienting the sea turtles and hatchlings.
6. Installing motion sensitive lighting that is activated only when necessary can drastically reduce artificial illumination without compromising security in residential and commercial areas.
7. Implementing legislations that would restrict coastal properties to use light during the nesting season.
8. Implementing coastal vegetation in front of the light sources such as residential buildings and hotels, this vegetation can act as a barrier from the light without requiring any drastic infrastructure changes. Although this would not help to reduce the sky glow, it is a measure that can have a positive response from the public as well.

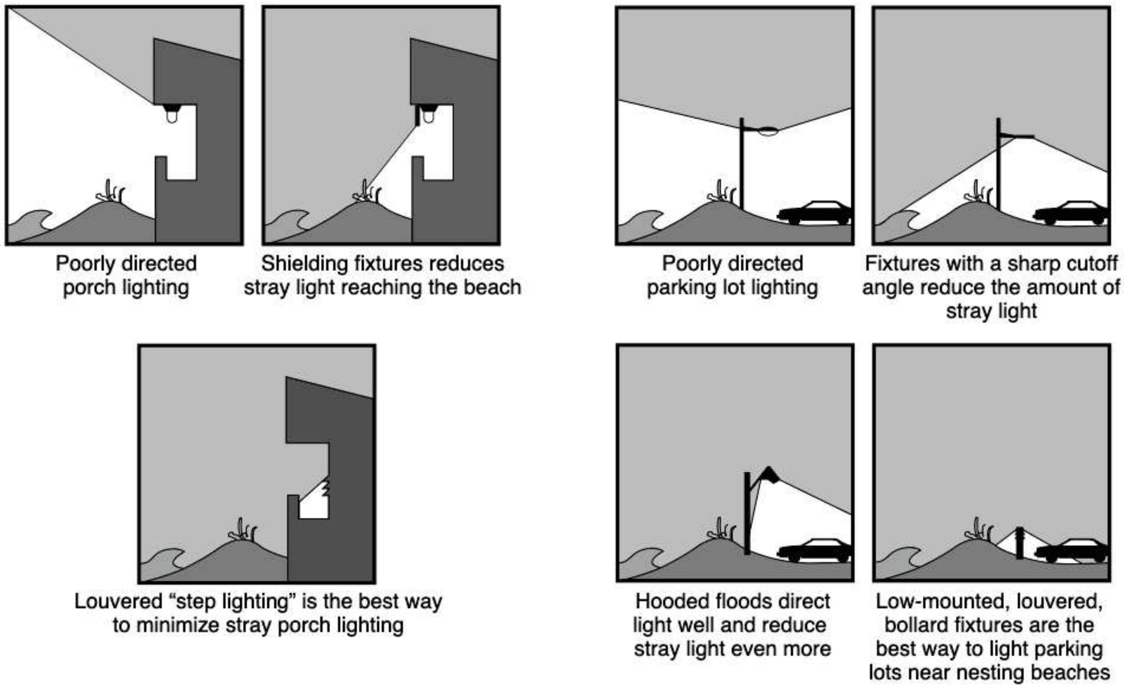


Figure 8.0. [Light management techniques for building and pole-mounted lighting near sea turtle nesting beaches. Witherington, 1999.]

Government and coastal authorities should enforce regulations to ensure beachfront development incorporates sea turtle friendly lighting in the newly identified nesting sites. Further, public education campaigns should benefit towards the welfare of these species by actively reminding owners, tourists and local residents of light pollution management for sea turtle conservation (Witherington and Martin, 2003). Seasonal restrictions between May and October that target restriction of bright light that can disorient nesting females and hatchlings is an effective way to mitigate this threat, if the said restrictions are enforced and controlled.

8.1.4 Poaching and Community-Based Solutions

Raising awareness about chelonitoxism can be an effective conservation strategy that may discourage the consumption of sea turtle meat. Chelonitoxism is a seafood poisoning linked to the consumption of contaminated with biotoxins sea turtle meat. Documented cases of chelonitoxism have affected over 2,400 individuals globally, with a high mortality rate, particularly in coastal communities where sea turtle consumption remains culturally significant despite conservation efforts (Semmouri et al., 2024). Symptoms range from gastrointestinal distress to neurological complications, sometimes leading to fatal outcomes (Semmouri et al., 2024).

To effectively eliminate poaching, the last anthropogenic threat discussed in this thesis, a careful approach is necessary, starting with strengthening legal frameworks and improving law enforcement in areas with high poaching rates, and engaging local communities in conservation initiatives. It is vital to acknowledge that discouraging traditional methods is not possible and may be viewed by the public as disrespectful, it could spike controversy and increase resistance to improve conservation for these species. Community-based conservation programs that integrate local traditions while promoting sea turtle protection is a much more sustainable approach. Programs that integrate local traditions while promoting sea turtle protection offer a more sustainable and inclusive approach to conservation. Investing in ecotourism, for instance, can shift public interest away from extractive or harmful practices such as poaching, and promote alternative, environmentally responsible sources of income. When local communities see economic benefits from protecting turtle nesting beaches, such as through guided tours and turtle watching experiences, they are more likely to take a step towards protecting these habitats. This transition not only fosters long-term support for conservation goals but also empowers local people by creating employment opportunities tied to the preservation of these species. Furthermore, implementing structured monitoring of trade routes and enhancing anti poaching patrols can create more jobs in these regions and successfully contribute to population growth.

8.2 Managing Natural Threats

8.2.1 Parasites and Diseases

Natural threats such as parasites and infectious agents mostly co-evolved with sea turtles in their long history and eliminating natural diseases would be unnecessary and counterproductive, as sea turtle population equilibrium with the ecosystem is also maintained by natural diseases. Parasitic diseases contribute to the mechanism of natural selection, reinforcing the population itself by eliminating the weakest individuals. Nevertheless, human-induced changes on the natural habitat may alter the epidemiology of such diseases, as the environment is a crucial element in shaping the equilibrium between host and infectious agents. Therefore, the focus should be put on conservation strategies and innovative solutions to limit as much as possible the alteration of the natural environment by human activities. Below, I propose evidence-based measures tailored to both old and newly established nesting sites, incorporating current best practices and ideas for future implementation.

When handling stranded sea turtles or those on shore, protective measures should be worn to reduce the potential for zoonotic contamination. Encouraging marine protected areas (MPAs) can restrict harmful human activities that could introduce harmful pathogens to the habitat. Regulation of heavy metal contamination is advised, as the EU Water Framework Directive mandates limits on toxic heavy metals like arsenic (As), cadmium (Cd), and mercury (Hg) in marine waters (Casale et al., 2018).

8.2.2 Predation

A possible solution to the predation threat is to provide a physical barrier on the incubating nests (cages, mesh covers) (Brown and Macdonald 1995, Casale et al., 2018). While a good solution when the nest is incubated, this would act as a barrier for hatchlings moving towards the sea. The said physical barriers must be removed prior to eggs hatching, and a physical barrier of human volunteers can be formed as a path, providing protection from predation and poaching and making sure every hatchling stays on the correct path. Further engaging the public during nesting and hatching season to relocate the nests and to protect the hatchlings while they make their way towards the water is a huge contribution to the survival success of these species.

Protection of the nest had proved to be successful in the past. A case study described in chapter 4.1.2, demonstrated a remarkable case of successful protection and hatching, achieved largely through the efforts of local associations and volunteers (Paterna, 2024). This case illustrated the effectiveness of low-impact interventions such as fencing, nocturnal monitoring with red LED lighting, and guided beach corridors to the sea. The relatively natural setting of the nesting site, despite some proximity to anthropogenic structures, further reinforced the necessity of maintaining undeveloped coastal habitats for sea turtle reproduction.

8.2.3 Climate Change

To safeguard sea turtle populations in the face of accelerating climate change, a range of adaptive and regionally specific conservation measures are required. Monitoring efforts should continue in areas where the nesting shift is taking place. Standardised and continuous data collection will be crucial for future identification of male-producing beaches, which will eventually be essential for maintaining sex ratio balance in future populations. Set back regulations should continue to be implemented and regulated throughout the whole Mediterranean. Nest relocation can act as a temporary solution to reduce excessive sand temperature effect on the sex ratio in critical sites.

In response to sea rise levels and coastal development, construction setback regulations play a critical role in safeguarding sea turtle nesting habitats by allowing natural beach migration. Studies on Caribbean islands, particularly in Barbados have shown that setbacks of 70 meters or more have proven effective in preserving nesting sites, unlike inadequate setbacks of 10 - 30 meters that have led to habitat loss (Fish et al., 2008). Given that Mediterranean sea turtle populations rely on undisturbed sandy beaches for reproduction, similar policies should be integrated into coastal zone management strategies. Implementing variable setback regulations based on beach slope, sediment dynamics, and projected erosion rates could ensure the long-term availability of nesting habitats while balancing economic and developmental interests.

Natural coastal processes such as erosion and accretion are inherent to beach dynamics but may be significantly exaggerated by anthropogenic threats. In general, minimal intervention is advised, unless turtle nests are in direct danger, as some level of erosion is a natural and a recoverable occurrence. Practice of beach armoring, which involves constructing seawalls and other barriers is not recommended. Such structures will intensify erosion and limit access to nesting females. As an alternative, artificial beach nourishment is often proposed, which consists of adding sand to eroded beaches. While it may pose fewer risks than beach armoring, nourishment must be conducted with highest caution,with the use of appropriate sand and avoiding any activating during the nesting season (Eckert et al., 1999, Witherington, 1999).

Although mitigating climate change threats may seem to be a step in the right direction, at times doing nothing is the best course to go about such threats, as turtles have evolved to withstand certain levels of environmental variability.

8.3 Nest Relocation and Hatchery Programs

Ideally, eggs should incubate in the natural nest (Mortimer, 1999). Relocation and nest protection programs that already exist throughout the Mediterranean is a possible solution for areas with high pathogen risks. Eggs are relocated within the first 2 hours (Mortimer, 1999) to safer beach zones and/or rescue centres with controlled moisture levels and tested for pathogens and to prevent fungal and bacterial infections. The managed humidity and sand aeration in rescue nesting sites prevents fungal overgrowth. Monitoring humidity and temperature in relocated nests can prevent fungal and bacterial growth. Nest relocation should only take place when in-situ nests can't be protected, in cases of flooding, poaching and human disturbance.

Hatching rearing programs are one of the most used strategies to maximise survival of the clutch. It is important to acknowledge that the beach selection for establishing hatcheries needs to be chosen carefully, as this will act as a nesting site to the relocated hatchling in the next 30+ years (Demetropoulos, 2009). Choose only those beaches that can be available long term for this conservation method. It is best if hatcheries are located on previously known and successful hatching beaches. If relocating many nests at once, stick to using diverse sites to avoid skewed sex ratios and overdependence on one beach, as mentioned previously, if occupied in the future by human activities, an entire subpopulation may be wiped out (Demetropoulos, 2009).

Hatcheries should be located as close to the beach as possible to minimise physical trauma along the way. Since the two species nest above the tide line, the nesting sites should be located at least 1 meter above the level of the highest tide to avoid flooding of the nest (Mortimer, 1999). The nest is to be covered with a mesh to protect from natural non-human predators. In some cases, to increase the clutch survival rate during incubation, eggs from the same clutch are positioned into two independent nests, 40-60 eggs per nest.

It is always best to use in-situ conservation strategies instead of relocating. Hatcheries are an expensive method in terms of financial and human resources. Moreover, they do not provide a guarantee for a 100% hatching success. In fact, hatching success is usually lower than in natural sites. This method creates a heavy dependence on humans and may be impossible to maintain over time (Mortimer, 1999).

8.4 Region-Specific Approaches

Although threats may be similar in different regions, particular conservation strategies should be emphasised depending on the severity and typology of the threats in different regions. Wallace et al. (2011) introduced the Regional Management Units (RMUs) framework, which allows for more precise conservation assessments by evaluating marine turtle populations based on their distinct genetic, ecological, and geographic characteristics. This study, which assessed 58 RMUs worldwide, identified 11 of the most endangered marine turtle populations, with the highest threats observed in the Indian Ocean and the East Pacific Ocean, regions where fisheries bycatch, habitat loss due to coastal development, and climate change have severely impacted turtle populations. In contrast, Wallace et al. (2011) classified the Mediterranean region as Low Risk-High Threat, meaning that while turtle populations in this area maintain relatively stable numbers, they face persistent and escalating environmental pressures. Wallace et al. (2011) identified coastal development, light pollution, and increasing human activities on nesting beaches as key threats that could affect population stability if left unmitigated. Although this study did not focus on the Mediterranean, the RMU approach provides a valuable model for assessing conservation priorities in this region, where similar threats, including increasing coastal construction and habitat degradation, jeopardize loggerhead and green turtle nesting sites. The application of RMUs to the Mediterranean could help identify high-risk nesting areas and refine conservation efforts.

Regionally targeted approaches are also necessary. For example, Calabria has shown elevated arsenic concentrations in sand, possibly linked to industrial pollution. In areas as such, conservation strategies must include regular monitoring of metal levels in beach substrates and prey species, with regulations to control marine litter and industrial pollution. Future research should expand to include heavy metal analysis in turtle eggs and establish health surveillance programmes for nesting females and juveniles. This could further enhance conservation outcomes by identifying and addressing potentially lethal stressors. The data from the monitoring can help strengthen Marine Protected Areas (MPAs). In

Cyprus, conservation actions began in early 1990s and if not for the efforts and presence of allocated Special Protected Areas (SPAs), the nesting sites could have been easily impacted by coastal development. These efforts illustrate how long term planning, combined with support of the government and scientific research, can eliminate anthropogenic threats.

To effectively safeguard Mediterranean sea turtle populations, it is essential to understand the conservation needs across different coastal nations. Table 1.0 in the Annex was developed by the author of this dissertation through a comprehensive analysis of the literature cited in the bibliography, and provides a comparative overview of the nesting activity, major anthropogenic and natural threats, poaching and predation levels, as well as conservation stakeholders and needs across key Mediterranean countries. By systematically evaluating such factors this table serves as a tool for identifying gaps and priorities in regional conservation planning and enables a clearer understanding of which areas require immediate intervention, where successful practices can be expanded, and how regional cooperation may be enhanced to protect sea turtle nesting habitats.

8.5 Recommendations for Improving Conservation Strategies

Mediterranean countries should take into consideration and adopt internationally recognised monitoring standards, such as SWOT's minimum data standards(SWOT Scientific Advisory Board, 2011) , to ensure consistency in data collection. In addition to the previous point, strengthen data-sharing networks across countries of the Mediterranean basin. Establish training programs and encourage long-term, multi-site monitoring to detect population trends and identify emerging and/or existing threats. Advocate for the expansion of Marine Protected Areas (MPAs) and Specially Protected Areas (SPAs), at the least during the nesting season, May to October. Only relocate nests when absolutely necessary. Further develop community based conservation programs that respect local traditions and promote economic alternatives such as eco-tourism and jobs in the conservation field (see chapter 9).

9. Public Engagement Projects

Conservation of marine turtles depends on the active involvement of all stakeholders involved. The effectiveness of current efforts relies on their continuity to ensure long term success. Starting with involving the younger generation to participate in activities such as “Turtle Walk”, a volunteer event implemented in highschools across India's breeding hotspots and throughout the world today. Students alongside rescue centre staff participate in early morning beach walks to locate and identify the tracks of the sea turtles. These events provide hands-on experiences with nest relocation techniques, including measuring nest dimensions and carefully extracting eggs for transfer to safer, artificial nests in nearby rescue centres. Most importantly, events as such excite the younger generation about getting involved in marine conservation through a deep emotional connection between youth and marine biodiversity. Students return weeks later to assist in the release of hatchlings, helping them safely reach the ocean waters while protecting them from predators and poachers. Such initiatives have been shown to inspire long term contribution to shaping awareness in the new generations, finally improving marine habitat conservation.

Beach clean ups also offer public contribution. In Italy in particular, an environmental NGO Marevivo actively engages local communities and organises beach clean ups throughout the Italian coastline. In recent years, Marevivo has strengthened their international collaborations with other EU countries. Apart from volunteer beach clean ups, this organisation alongside the international partners is actively involved in the protection of the loggerhead nests along the Italian coast. This year between June and October, the Life TURTLENEST (2025) project is taking place, where groups of volunteers will participate in daily conservation practices including tracking turtle nesting activity, guarding nests, raising public awareness, and supporting hatchling success in Campania and Lazio. The project is carried out in collaboration with France and Spain, reflecting the Mediterranean commitment to biodiversity conservation.

The Sea Turtle Protection Society of Greece, ARCHELON, promotes public engagement that combines scientific monitoring with community involvement to protect Mediterranean sea turtles, in particular the loggerhead. Through its network of volunteer based projects across key nesting areas such as Zakynthos, Crete and the Peloponnese, ARCHELON facilitates public participation in sea turtle conservation by training volunteers to monitor nesting activity, protect nests and mitigate human induced threats like light pollution and beach obstacles. Additionally, Greece recognises sporadic nesting events and encourages local residents and tourists in safeguarding unmonitored nests by encouraging the public to report sightings and follow protection guidelines. This so-called citizen science approach strengthens data collections, habitat management and promotes environmental awareness among all stakeholders involved.

Social media platforms can serve as cost-effective tools for gathering data on sea turtle strandings, nesting activities, and poaching incidents, especially in remote and unmonitored areas that lack systematic monitoring, have limited funding, and experience ongoing political conflicts. In areas lacking such systems, such as Libya (Rizgalla 2021) in the period between 2010 and 2020, social media has proven effective for reporting poaching and stranding events. Public engagement in the form of social media posts can play a vital role in data collection and protection strategies when other resources are not available. Social media has proved to be a successful tool in Black sea in documenting marine mammal sightings in the past, when the researchers could only rely on the public in order to gather more data (Węgrzyn et al., 2023).

In Maldives, the Olive Ridley project introduced another model of public-private engagement. Regular training sessions are conducted with hotel resort security staff, who petrol beaches for security purposes and report turtle nesting activities. This is a perfect example of a partnership between conservationists and the tourism sector that ensures early intervention in nesting events and can increase survival rates for both nests and hatchlings. In areas that lack trained staff to petrol the nesting beaches, students of animal fields and volunteers in animal organisations can get involved.

The protection of turtle nesting sites and beaches not only benefits marine turtles but also to the coastal ecosystem as a whole (Jribi et al., 2023). By continuing to raise public awareness, strengthening international collaborations, contributing to habitat protection and restoration and in depth research of marine turtle populations, these efforts continue to contribute to the overall welfare and ensure a more promising future for the two species inhabiting the Mediterranean waters.

The effectiveness of these strategies can be evaluated through future recurrence of nesting and nest counts. Given that in the upcoming years, the Mediterranean region begins to document a higher annual nest count, it can be safely concluded that the conservation measures have a positive impact on the subpopulation growth of the loggerhead and the green turtles.

Conclusion

The Mediterranean region is a critical habitat for the loggerhead and the green turtle that depend on the suitable nesting beaches to complete their life cycles. This bachelor level dissertation has examined characteristics and nesting ecology of these species, identifying key nesting sites and migratory shifts, as well as major anthropogenic and natural threats they face. Current conservation efforts, including legislative frameworks, marine protected areas and public engagement projects, have shown effectiveness. Regions such as Cyprus and Turkey provide evidence that long term conservation initiatives can lead to significant increases in nesting activity and hatchling survival. What needs to be acknowledged is that challenges are often region specific, and will require locally adapted and evidence based strategies.

In conclusion, safeguarding Mediterranean nesting beaches requires a precise approach. Firstly, legislation must not only be established but also enforced, especially in countries where protective frameworks are weak or are not in action. Then, public education and stakeholder collaboration, particularly with the tourism industry, are essential to ensure long term community support. Furthermore, monitoring programs must be expanded, particularly in newly emerging nesting sites such as those in the Western and Northern Mediterranean, as climate change continues to shift nesting and foraging ranges. The conservation of the loggerhead and the green turtle in the Mediterranean is not only a matter of species protection but also on a larger scale a contribution to marine biodiversity and ecosystem.

Protecting sea turtle nesting beaches is not just an environmental duty, it is an act of commitment to the state of our seas.

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Annex

REGION	NESTING BEACH/AREA	LENGTH (KM)	AVERAGE Nests/year (Most recent 5-yr period)
Greece	Southern Kyparissia Bay	9.5	1403
Greece	Laganas Bay, Zakinthos	5.5	938
Turkey	Anamur	12	791
Cyprus	Chrysochou Bay	12	658
Turkey	Belek	16	628
Turkey	Dalyan	4.7	307
Greece	Rethymno, Crete	10.8	275
Cyprus	West Coast	5	249
Greece	Lakonikos Bay	23.5	190
Turkey	Fenike-Kumluca	21	184
Turkey	Patara	14	180
Turkey	Kizilot	8.5	138
Turkey	Demirtas	7.8	137
Turkey	Göksu Delta	34.7	124
Libya	Al-Gbeba	5.7	122
Libya	Al-Arbaeen	8.5	119
Libya	Al-Metefla	4.5	104
Greece	Northern Kyparissia Bay	34	102
Cyprus	Akdeiz Beches (Morphou Bay)	8.6	101
Turkey	Cirali	3.2	86
Turkey	Dalaman	10.4	86
Turkey	Fethiye	8.3	84
Libya	Al--Thalateen	5	73
Greece	Beaches adjancent to Kiparissia town	3.5	68
Greece	Kos Island	23	60
Greece	Bay of Chania, Crete	13.1	60

REGION	NESTING BEACH/AREA	LENGTH (KM)	AVERAGE Nests/year (Most recent 5-yr period)
Cyprus	Alagadi (Alakati)	1.7	59
Greece	Koroni	2.7	56
Lebanon	El-Mansouri	1.4	55
Cyprus	East Coast	6.6	53
Turkey	Kale-Demre	8.5	52
Cyprus	North Coast	2.7	50
Greece	Lefkas Island	17.13	50
Cyprus	Guzelyali (Vasilia)	1	45
Greece	Messaras Bay, Crete	8.1	45
Cyprus	South Karpaza	7.6	41
Cyprus	South East Karpaz	7.2	41
Cyprus	Tatlisu (Akanthou)	0.3	38
Libya	Semeda	9.4	34
Greece	Mounda, Kefalonia	2.8	29
Libya	Ain Ghazala	1.4	26
Greece	Romanos	2.7	25
Libya	West Camp	2.5	25
Turkey	Alata	3	25
Libya	Al-Gwezat	5.5	23
Tunisia	Great Kuriat*	0.9	22
Libya	Al Arar	7	22
Cyprus	North Karpaz	4.4	22
Greece	Kerkyra Island (Corfu)	7.8	20
Libya	Al Malfa	1.5	20
Libya	Eogla	3.9	17
Libya	Elmabulha	5.3	16

Figure A [Loggerhead turtle nesting locations in the Mediterranean with >10 nests/year in the most recent 5 year period. Beach length referred to surveyed length. Casale et al., 2018, Hochscheid et al., 2018 and Katsiyiannis, 2019]

REGION	NESTING BEACH/AREA	LENGTH (KM)	AVERAGE Nests/year (Most recent 5-yr period)
Turkey	Kazanli	4.5	365
Turkey	Akyatan	22	322
Turkey	Samandag	14	306
Cyprus	Ayios Philon & Ronnas Beach	3.2	220
Turkey	Sugözu	3.4	213
Cyprus	Alagadi(Alakati)	1.7	154
Syria	Latakia	12	140
Turkey	Alata	3	125
Turkey	Davultepe	2.8	113
Cyprus	West Coast	5	108
Cyprus	Akdeniz Beach (Morphou Bay)	8.6	70
Cyprus	South Karpaz	7.6	59
Cyprus	North Coast	2.7	11

Colors in tables indicating the different protected areas

National Designated Areas

Sites of Community Importance (EU Natura2000)

National Designated Areas and Natura 2000 sites

International Designated Areas (RAMSAR sites)

* Proposed MPA

Figure B [Green turtle nesting locations in the Mediterranean with >10 nests/year. Casale et al., 2018]

Country	Coast Line (km)	Species	Nesting Status	Protection Laws and Threaties	Major Threats	Poaching level	Predation level	Conservation stakeholders	Conservation Needs
Cyprus	648	both	Major	Barcelona Bern Bonn CITES D. Habitat SPA	Coastal development (**) Climate change (female sex ratios) Pollution (debris) Presence of people at night Vehicles on the beach	Past	Low (5%) Past (high)	CWS*, SPOT	Establish network of Marine Protected Areas Funding & training to monitor nesting behaviour Law enforcement Litter management
Greece	13676	Cc	Major	Barcelona Bern Bonn CITES D. Habitat	Absence of dune Coastal Development (*) Dynamite fishing Erosion Pollution (light, debris) Tourism (Beach furniture) Vehicle Driving	Absent	Moderate	ARCHELON, Katelios group, MEDASSET, WWF-Greece	Beach restoration Educate public and tourism industry Government cooperation Law enforcement Nest management (shading the nest) Predation control
Libya	2000	Cc	Major	ACCOBAMS African conv. Barcelona CBD CITES CMS National Law SPA	Dynamite fishing Pollution (debris, oil) Tourism Vehicles on the beach	Low	Moderate	EGA* (Libyan Sea turtle program), MEDASSET, UNEP-MAP, RAC/SPA, Universities, WWF	Develop dynamite fishing study Establish network of Marine Protected Areas Establish stranding network Funding education and programs Law enforcement Partner Internationally
Turkey	2577 (606)	both	Major	Barcelona Bern CITES National Law Rio conv.	Artificial Light Coastal development Erosion Tourism Pollution (debris, chemical contamination, heavy metal) Vehicles on the beach	Moderate	High	Ekad, Public, Universities, WWF-Turkey	Establish rescue centres Funding education and programs for monitoring nesting sites Law enforcement
Albania	147	Cc	Sporadic	Bern Bonn CITES Ramsar	Coastal development (*) Dynamite fishing Erosion	Absent	Absent		Funding study programs Pollution (litter) management Tagging program Training
Croatia	1777 with island 5835	Cc	No nesting	Barcelona Bern, Bonn CBD CITES Nature Protection Act Red Book SPA	NOT APPLICABLE No nesting Coastal development (*) Tourism	Past	Absent	Private, Universities and Institutes	Educate and allocate funds for research Establish a stranding network Implement national level authority

Egypt	3049	both	Sporadic	Africa conv. Barcelona Bonn CITES National Law SPA	Coastal development (**) Intentional killing and exploitation Pollution (debris) Tourism	High	High	EEAA*, International, MEDASSET, NGO, WWF	Educate public Research and monitoring of nests
Israel	273	both	Sporadic	Barcelona Bonn CBD National Law Ramsar conv.	Disease Erosion Storm and weakness	Absent	High	Israel Nature and Parks Authority, Underwater Observatory Marine park in Eilat	Action plan of sand erosion Funding study programs to monitor nesting
Italy	7000	Cc	Sporadic	Barcelona Bern CBD CITES CMS D. Habitat National Law	Coastal development Erosion Pollution (light, heavy metals, organochlorine pesticides) Tourism (beach furniture) Vehicles on the beach	Past	Low	Aquariums, ARCHE', Cicily wildlife fund, MAREVIVO, Public, Private, Universities, WWF-Italia	Educate fisherman
Lebanon	200	both	Sporadic	National law UNEP-MAP	Absence of dunes Dynamite fishing Coastal development (military impact) Erosion Lack of data (studied began 2001) Pollution (debris, chemical contamination) Short beaches Military impact	Unknown	Moderate	Local NGOs, MEDASSET, Palm Island Nature reserve, TCNR, Tyre Coast Nature Reserve, Universities	Enforce and implement management plans Enforce international cooperation Long term nest monitoring programs Run awareness campaigns Sand dune protection
Malta	196	Cc	Sporadic past	ACCOBAMS Barcelona Bern, Bonn CBD, CITES D. Habitat National Law Ramsar SPA SPABIM protocol UNCLOS UNFCCC UNCCD World heritage conv.	Coastal development (***) Erosion Tourism Artificial light Absence of dune Tourism (human presence)	Absent	Absent	BICREF, Nature Trust, NGO, University of Malta	Conduct surveys to estimate population abundance and distribution

Morocco	490	Cc	No nesting	Barcelona Bern Bonn CBD National Law - 500€ fine	Rock beach Strandings	Low	Absent	ATOMM, INRH*, SPANA*, Universities	Education Establish monitoring team Establish involvement of the government Strengthen international cooperation
Syria	183	both	Sporadic	Barcelona Bonn CITES	Artificial light Rock beach Pollution (debris) Vehicle presence	Absent	Moderate	SSAEP*, University Ministry of Agriculture/ local administration and environment	Fund education and training
Tunisia	1250	Cc	Sporadic	Algiers Barcelona Bern Bonn CBD CITES National Law SPA World heritage conv.	Coastal development (partially) Tourism	High	High	INSTM*, Universities, WWF	Establish public awareness program Identify nesting sites Protection and management of existing nesting sites
Slovenia	44	-	No nesting	Barcelona Bern Bonn CBD CITES D. Habitat National Law	Rock beach Pollution (water, in water debris, heavy metal)	Absent	Absent	Aquarium, Biocen, Institutes, Morigenos	Establish monitoring and research programs Fishing legislation and law enforcement
France	5500	Cc	Emerging	Barcelona Bern Bonn CITES D. Habitat	Coastal development Cliffs Erosion	Absent	Absent	CESTMED*, Government, RTMMF*	Reduce bycatch impact through fisherman education programs
Spain	8000	Cc	Emerging to Sporadi	CITES D. Habitat National Law	Artificial light Beach restoration Coastal development (*) Parasites Pollution (debris, heavy metal) Tourism	Absent	Absent	NGOs, Private organisations, Universities	Assess population abundance and nesting events Establish monitoring and research programs Establish network of Marine Protected Areas Public education

Table 1.0 Species; Cc - the loggerhead turtle *(Caretta caretta)*, Cm - the green turtle *(Chelonia mydas)*, both - both species the loggerhead turtle *(Caretta caretta)* and the green turtle *(Chelonia mydas)*. Major Threats; (*) - the trends of the threat are increasing, (**) - the trends of the threat are increasing and are damaging to the population, (***) the trends of the threat are heavy and contributed to the wipe out of nesting activity. Poaching level/ Predation level; Absent - no recorded cases as of today of poaching, Low - rare incidents or isolated reports, Moderate - Occasional reports, High - frequent or severe impact on eggs or adult turtles, Unknown - data not available, Past - previously significant, but currently absent due to successful mitigation. Conservation stakeholders; CWS - Cyprus Wildlife Society, EEAA - the Egyptian environmental affairs agency, RTMMF - The French Mediterranean Marine Turtle network, CESTMED - rescue centre, INRH - National Institute of Halieutic research, SPANA - Protective company of Animals and Nature, INSTM - National Institute of Marine Science and Technology, SSAEP - Syrian society for aquatic environment protection, EGA - environmental general authority.

Guide for Animal Care students interested in organising a beach clean-up.

How to Organise a Beach Clean-Up in Italy

(Marevivo Guidelines)

According to Marevivo's guide, these are the essential steps to keep in mind when organising a beach clean up (links are provided at the end of the document):

Before the Clean-Up

Choose a Beach by identifying a location that is accessible and safe for volunteers. Obtain permission if the area falls under protected or private territory.

Notify Authorities by contacting local municipalities or managing authorities to inform them and request collaboration or permits.

(Numbers of all municipalities and commune can be found in the following link: https://www.comuni-italiani.it)

Assemble a team that involves classmates, associations, or community members. Assign roles such as safety manager, photographer, or waste sorter.

Promote the event through the use of social media, posters, and local outreach to involve more participants. By contacting MAREVIVO directly, you can ensure your event gets visibility through their channels. Email: volontari@marevivo.it, Telephone Number: +39 063222565.

Prepare educational materials about marine pollution and the impact on sea life to share with participants and curious public passing by.

During the Clean-Up

Registration & Safety Briefing. Have a registration point and explain safety rules.

Distribute materials such as gloves, bags, tongs, and separate bags for different types of waste (plastic, metal, glass, etc.). The commune will provide you with material for waste upon your request.

Collect waste responsibly. Avoid disturbing natural habitats. Report large or hazardous waste to the local authorities and do not handle it by yourself. Provide a first aid kit on site for potential injuries.

After the Clean-Up

Waste disposal. Coordinate with the local municipality for correct disposal and recycling.

Take photos and **share** results. Document data such as the amount and type of waste collected and send it to environmental organizations like Marevivo.

For further information refer to https://marevivo.it/attivita/beach-cleanup/

How to Organise a Beach Clean-Up in Venice
(Comune di Venezia Procedure)
(https://www.comune.venezia.it/it/content/eventi-clean)

In Venice, organising a clean-up event involves specific legal and administrative steps. For the specific instructions for any other commune, refer to official commune websites and/or contact MAREVIVO for further information and guidance.

1. **Submit a formal request** (30+ Days in advance)

Include organiser details, location (with a map), program outline, times, estimated participants, and how the event will be conducted. An official pdf document needs to be filled out and sent to the commune through the following channels (document link attached down below).

If you're an association, company, or school, send the request via PEC to:
territorio@pec.comune.venezia.it

If you are a private citizen without PEC, send it to:
servizio.ambiente@comune.venezia.it

2. **Coordinate with Authorities**

The Municipality will assess compliance and coordinate with VERITAS Spa to provide support with waste collection and disposal. For protected areas (example; Alberoni, Ca' Roman), additional restrictions may apply.

3. **Notify Local Police Headquarters**

Report the event to the Venice Police Headquarters at least 3 days prior by emailing:
dipps192.00F0@pecps.poliziadistato.it

4. **Ensure safety and responsibility**

Make sure you provide gloves and appropriate footwear to participants. Keep track of all volunteers upon arrival and keep in mind that organizers are liable for any damages or issues during the event. Use this as an opportunity to engage local communities and to educate the public on the importance of keeping our environment clean! Clean with care and responsibility! All the best animal care students!

Formal request PDF*
https://www.comune.venezia.it/sites/comune.venezia.it/files/documenti/Ambiente/Modulo%20istanza%20_cleanup_editabile_26sett2024.pdf

*The editable version can be downloaded on the commune website