N° d'ordre : ……

الجمهورية الجزائرية الديموقراطية الشعبية

People's Democratic Republic of Algeria

وزارة التعليم العالي والبحث العلمي

Ministry of Higher Education and Scientific Research

معهد العلوم البيطرية

Institute of Veterinary Sciences

جامعة البليدة -1

Blida-1 university

Final Project Study for the obtaining of

the Doctor of Veterinary Medicine diploma

Analysis of marine turtle's strandings along the central Algerian coastline

Presented by

LANDRI Youcef
ACHOUR Mohamed Samy

Defended on **02/07/2024**

Presented to the jury:

President :	BOUKENAOUI N.	*Professor*	I.S.V.Blida 1
Examiner :	LAGHOUATI A.	*Senior lecturer*	I.S.V.Blida 1
Promoter :	NEBRI R.	*Associate professor*	I.S.V.Blida 1

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ACKNOWLEDGMENT

With a heart overflowing with gratitude, we first and foremost honor **Allah**, the Almighty, for His unwavering blessings. His divine grace has granted us the strength, resilience, and unwavering spirit to persevere through our academic journey and bring this work to completion.

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We extend our deepest gratitude to all the amazing teachers who've been there for us from the start to the finish line.

DEDICATIONS

This project is a culmination of years of effort, but it wouldn't be possible without the foundation you provided. **Mom and Dad**, your endless love, support and belief in me fueled my determination even when the path grew daunting.

To my **brothers** and **family**, your unwavering support went beyond words. You are the constant reminder that I am never truly alone.

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Here, I want to extend a special thanks to the wonderful vets at **TAGAST veterinary clinic**. Your dedication to animal health and your support for my academic pursuits have played a vital role in shaping my path, and I am forever grateful.

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thank you.

Youcef

DEDICATIONS

Mes parents, piliers de mon existence, Votre amour inconditionnel m'a porté, Votre soutien indéfectible, ma récompense, Ce mémoire est le fruit de vos sacrifices, ma fierté

Chers frère et sœurs, complices de toujours, Votre présence a illuminé mes jours, Que ce mémoire soit un hommage à notre parcours, Et un gage de notre amour qui ne faiblira jamais

Chers confrères et consœurs, compagnons de lutte, Ensemble nous avons surmonté les obstacles, Que ce mémoire soit le témoignage de notre détermination.

Chers amis Que ce mémoire soit un reflet de notre amitié, sans fin.

Que ce mémoire soit un hommage à tous ceux qui ont contribué à mon succès, un témoignage de ma gratitude éternelle.

Sous le voile étoilé de la nuit, Où les galaxies dansent leur ballet, Je dédie ces mots à toi,

Toi qui illumines ma vie d'un éclat de feu follet plein de couleur face à l'obscurité.

Samy

ABSTRACT

Between September 2023 and June 2024, a survey was carried out in three coastal wilayas, namely Boumerdes, Algiers and Tipasa, to identify marine turtle strandings. The investigation revealed that the *Caretta caretta* loggerhead sea turtle was the only species stranded, with a total of 7 recorded, 5 of them in the west of Tipasa, on the coasts of the communes of Gouraya, Larhat and Damous in the far west of the wilaya. Two other female loggerheads were found in Ain Benian near Algiers, injured and having ingested plastic. Our survey findings indicate that loggerhead turtles strand throughout the year, independent of any specific seasonal pattern. The distribution of strandings by coastal wilaya shows a slight dominance along the sandy coasts of Tipasa and Algiers, while no loggerhead turtle strandings have been observed on coasts where the sand has been replaced by pebbles, such as Boumerdes. In terms of evidence of interaction with humans, the main cause of the loggerhead turtle strandings is thought to be accidental capture by small-scale fisheries, as well as collisions with boats. The Algerian data show that human activities affect loggerhead turtles.

ملخص

بين سبتمبر 2023 ويونيو 2024، تم إجراء إستطلاع في ثلاث ولايات ساحلية، وهي بومرداس والجزائر العاصمة وتيبازة، لتحديد السلاحف البحرية التي جنحت. كشف التحقيق أن السلحفاة البحرية من نوع كاريتا كاريتا هي النوع الوحيد الذي جنح من السلاحف البحرية حيث تم تسجيل 7سلاحف.5 منها في غرب تيبازة على سواحل بلديات قوراية والأرهاط والداموس في أقصى غرب الولاية. كما تم العثور على أنثيين أخريين في عين بنيان بالقرب من الجزائر العاصمة، مصابتين ومبتلعتين للبلاستيك. أظهرت نتائجنا أن السلاحف تتعرض للجنوح على الشواطئ طوال العام، بغض النظر عن الموسم. يُظهر توزيع تيهان السلاحف لوجرهيد حسب الولاية الساحلية هيمنة طفيفة على طول السواحل الرملية لتيبازة والجزائر العاصمة، في حين لم يتم رصد أي تيهان للسلاحف لوجرهيد على السواحل التي استبدلت فيها الرمال بالحصى مثل بومرداس. فيما يتعلق بالأدلة على التفاعل مع البشر، يُعتقد أن السبب الرئيسي لجنوح السلاحف هو الصيد العرضي من قبل مصايد الأسماك الصغيرة، وكذلك الاصطدام بالقوارب. وتظهر البيانات الجزائرية أن الأنشطة البشرية تؤثر على السلاحف ضخمة الرأس.

RESUME

Entre septembre 2023 et juin 2024, une enquête a été menée dans trois wilaya côtières à savoir Boumerdes, Alger, et Tipasa dans le but de recenser les échouages de tortues marines. Cette enquête a révélé que la tortue caouanne *Caretta caretta* était la seule espèce échouée 7 au total en été recensées 5 à l'Ouest de Tipasa dans les côtes relevant des communes de Gouraya, Larhat, et Damous dans l'extrême ouest de la wilaya. Deux autres femelles caouanes blessées et ayant ingérées du plastique et ont été trouvées à Ain Benian près d'Alger. Nos résultats d'enquête indiquent que les tortues s'échouent sur le rivage toute l'année, indépendamment de toute saisonnalité particulière. La répartition des échouages par wilaya côtière montre une légère dominance le long des côtes sablonneuses de Tipasa et d'Alger tandis que les côtes dont le sable est remplacé par les galets comme Boumerdes l'échouage de la tortue caouane n'a pas été observé. En ce qui concerne les preuves d'interactions avec les humains, la principale cause d'échouage chez les tortues caouannes serait les captures accidentelles par les pêcheries artisanales, ainsi que des collisions avec les bateaux. Les données algériennes montrent que les activités humaines affectent les tortues caouannes.

SUMMARY

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Abbreviations List

- CCL: curved carapace length
- IUCN: International Union for Conservation of Nature and Natural Resources.
- LAG: lines of arrested growth
- N: stranding records
- PTL: Post-cloacal tail length
- SCL: straight carapace length
- TSD: temperature-dependent sex determination
- TTL: Total tail length

INTRODUCTION

INTRODUCTION

Sea turtle strandings represent a globally significant issue a stark reminder of the numerous threats these creatures face. Several seasoned researchers have documented the declining populations of various sea turtle species, highlighting the urgent need for conservation efforts **(1).** The algerian coastline, with its diverse marine ecosystems, serves as a critical habitat for these reptiles **(2).** However, strandings along this stretch of the Mediterranean Sea raise concerns about their well-being **(2).** Our study delves into this issue, aiming to contribute valuable insights into the phenomenon of sea turtle strandings in Algeria. The research is structured into three chapters: The first chapter establishes a foundational knowledge by exploring the classification of various sea turtle species, familiarizing with their characteristics and ecological roles. The second chapter delves deeper into the specific context of the Mediterranean region, examining existing research on sea turtle strandings within this basin. The third one forms the core of our investigation, presenting the details of our investigation. This section encompasses a wide range of aspects, investigating into the methodologies employed during our fieldwork and the examination processes conducted in the laboratory and finishing with the presentation of our results. Here, we engage in a critical discussion, comparing our data with the existing data base from others. This analysis allows for a better understanding of sea turtle strandings, fostering a more comprehensive perspective on the challenges these creatures face.

By striving to synthesize all the information gathered, we aim to present a significant contribution to the ongoing efforts to conserve and protect sea turtles and offer valuable information for future research endeavors.

Bibliographic part

CHAPTER I: BIBLIOGRAPHIC SPECIE'S OVERVIEW

I.1. Scientific classification of sea turtles

There are over 300 species of turtles on our planet. Around 250 live in freshwater, wetlands, and swamps, 60 are exclusively terrestrial, and only seven are marine **(1)**. These are the leatherback sea turtle (*Dermochelys coriacea* by Vandelli, 1761), the loggerhead sea turtle (*Caretta caretta* by Linnaeus, 1758), the hawksbill sea turtle (*Eretmochelys imbricata* by Linnaeus, 1766), the green sea turtle (*Chelonia mydas* by Linnaeus, 1758), the flatback sea turtle (*Natator depressus* by Garman, 1904), the olive ridley sea turtle (*Lepidochelys olivacea* by Eschscholtz, 1829), and the Kemp's ridley sea turtle (*Lepidochelys kempii* by Garman, 1880). The last six belong to the family **Cheloniidae** and have a shell without a keel covered in scales and one or two claws on their flippers. Only the leatherback sea turtle is part of the family **Dermochelyidae**, which is characterized by the absence of horn and scales on its shell **(1)**. The Mediterranean Sea houses three frequently encountered sea turtle species:

Leatherback (*Dermochelys coriacea*): Widely distributed throughout the Mediterranean, these turtles are the largest living sea turtle species.

Loggerhead (*Caretta caretta*): The most common sea turtle in the Mediterranean, loggerheads nest on beaches throughout the region.

Green turtles (*Chelonia mydas*): These primarily herbivorous turtles occasionally occur in the Mediterranean **(3).**

Only the loggerhead and leatherback turtles are known to reproduce within the Mediterranean basin. This limited breeding activity raises concerns about the long-term sustainability of these populations. Both species unfortunately fall under the **"vulnerable"** category on the IUCN Red List, highlighting their need for conservation efforts **(4).** However, the green turtle is Classified as **"endangered"**, their presence in the Mediterranean is decreasing, pushing them closer to the brink of extinction **(5).**

Within the Mediterranean Sea, the taxonomic classification of sea turtles differentiates between distinct species based upon their unique morphological characteristics and established evolutionary lineages.

I.1.1. Taxonomy of leatherback sea turtle (*Dermochelys coriacea*)

Dermochelys coriacea is the only species in genus Dermochelys which stands alone as the sole extant representative within the family **Dermochelyidae (6).** The scientific name for this turtle *Dermochelys coriacea* in latin which translates to "leathery shelled turtle" describes the unique, soft, leathery texture of its carapace, unlike other turtles with hard shells **(7)** According to Rhodin and al **(8)**:

- Kingdom : Animalia
- Phylum : Chordata
- Class : Reptilia
- Order : Testudines
- Family : Dermochelyidae
- Genus : *Dermochelys*
- Species : *Dermochelys coriacea*

Figure 1 shows an image of a leatherback sea turtle**.**

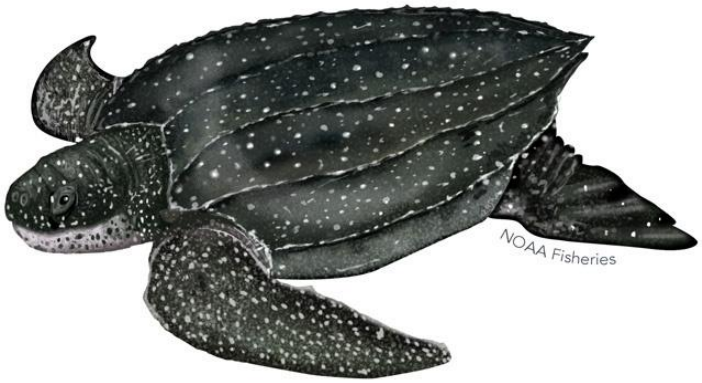

Figure 1 : Leatherback turtle (*Dermochelys coriacea)* **(9)**

I.1.2. Taxonomy of green sea turtle (*Chelonia mydas*)

Scientists consider the green turtle (*Chelonia mydas*) to be a circumglobal morpho-species. This means it's a single species found worldwide, but with distinct populations. Each population can be identified by its nesting beaches and contributes to the overall genetic diversity of the species. All populations are crucial for the green turtle's evolution and survival **(10).** According to Rhodin and al **(11)**:

- Kingdom: Animalia
- Phylum: Chordata
- Class: Reptilia
- Order: Testudines
- Family: Cheloniidae
- Genus: *Chelonia*
- species: *Chelonia mydas*

I.1.3. Taxonomy of loggerhead sea turtle (*Caretta caretta*)

- Kingdom: Animalia
- Phylum: Chordata
- Class: Reptilia
- Order: Testudines
- Family: Cheloniidae
- Genus: *Caretta*
- Species: *Caretta caretta*

The loggerhead turtle was initially described by Carl Linnaeus in 1758 as Testudo caretta, the species received 35 names however *Caretta caretta* was established as the valid scientific name **(12-13).**

I.2. Physical appearance

I.2.1. Overviews

Sea turtles are characterized by their large, streamlined shells and unique anatomy. Their shells, which consist of a top piece called the **carapace** and a bottom piece called the **plastron**, offer protection from predators and abrasions. These shells are bony and grow with the turtle throughout its life. Unlike other turtles, they cannot retract their head and limbs into their shells, so they have evolved flippers for swimming instead **(14)**.

The 2nd figure illustrates some of the external morphological structures used to identify sea turtles to species. These structures can also be used to reference a specific point on the body of a turtle such as the exact location of an injury, scute anomaly ... When many **scutes** or plates share the same name (like "vertebral" or "marginal"), scientists use a system to tell them apart. They assign numbers to each scute, starting from the front (anterior) and moving back (posterior). They also specify the left or right side of the body. For example, they might call a particular scute the "sixth right marginal scute"**(15).**

Figure 2 illustrates the external morphological features of sea turtles including the scutes where (a) shows the plastron's and (b) shows the carapace's**.**

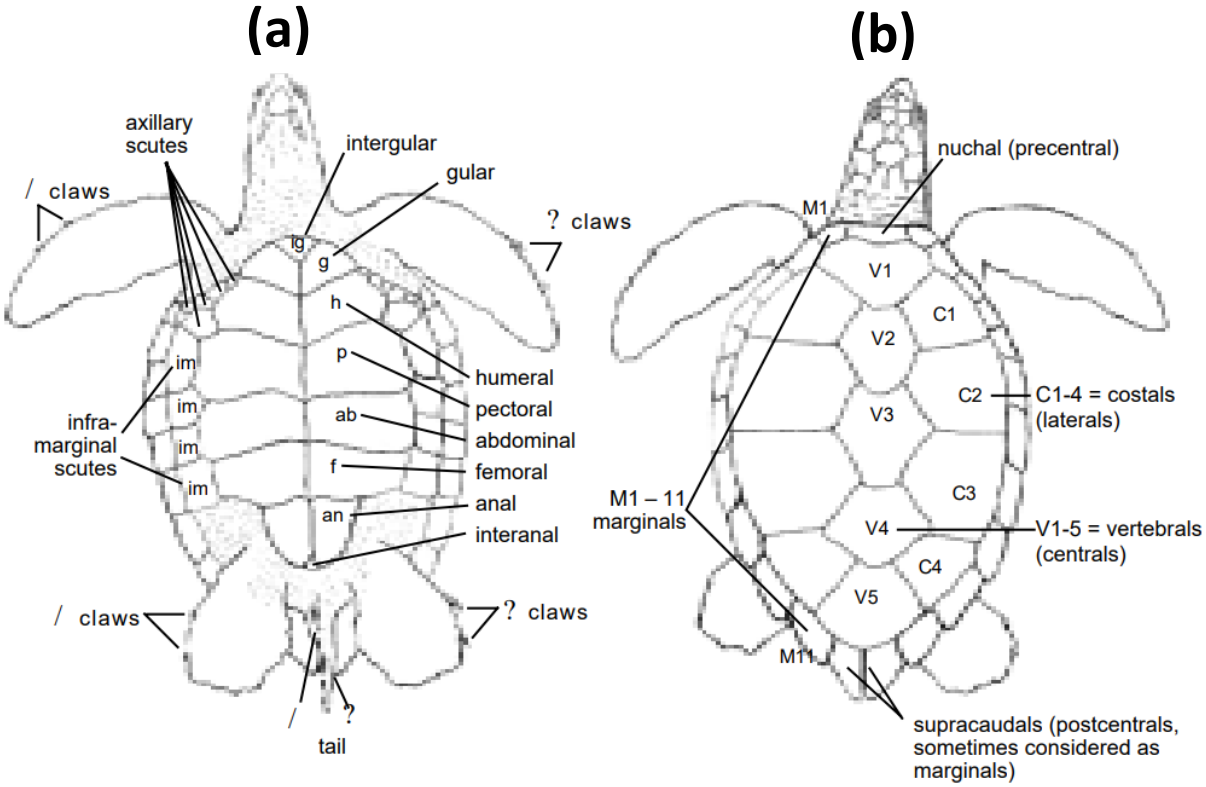

Figure 2: An illustrated guide to external morphological features of sea turtles including scutes of the plastron and carapace **(15)**

Noting the location of the pre-frontal and post-orbital **scales** on sea turtle's heads are diagnostic in the identification of some species. For example, we note one pair of pre-frontals and usually four pairs of post-orbitals in Chelonia. Adult leatherback turtles lack head scales **(15).** Figure 3 illustrates the anatomical features of:

(a) the leatherback turtle's head

(b) the green turtle's head

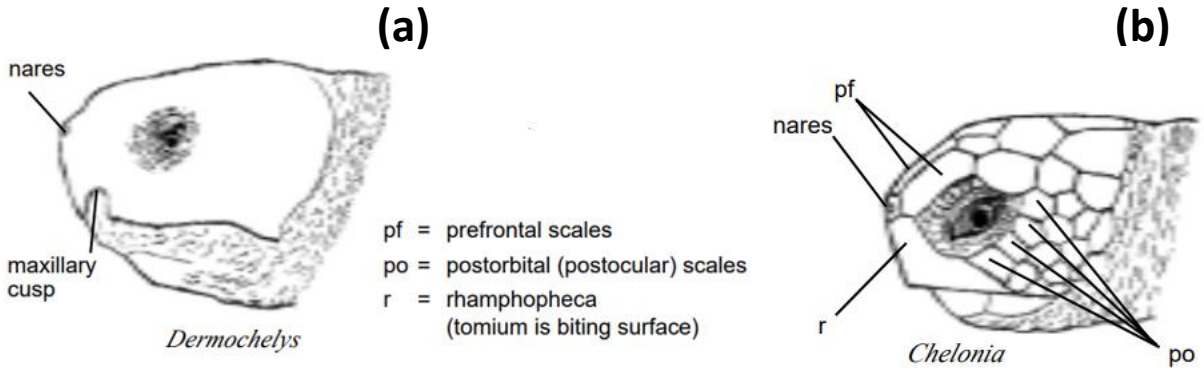

Figure 3: Anatomical features of leatherback and green turtle's head **(15)**

I.2.2. External Morphological structures of the loggerhead turtle

The Loggerhead Sea Turtle gets its name from its relatively large head and powerful beak, which are prominent features compared to other sea turtle species **(16).** The head is broadly triangular in shape, width to 28 cm with two pairs of prefrontal scales **(15)** the animal's head is reddish-brown as is the carapace (top shell), and both may be tinged with olive **(16).**

Figure 4 illustrates the external morphological features of the loggerhead sea turtle's head from three points of view

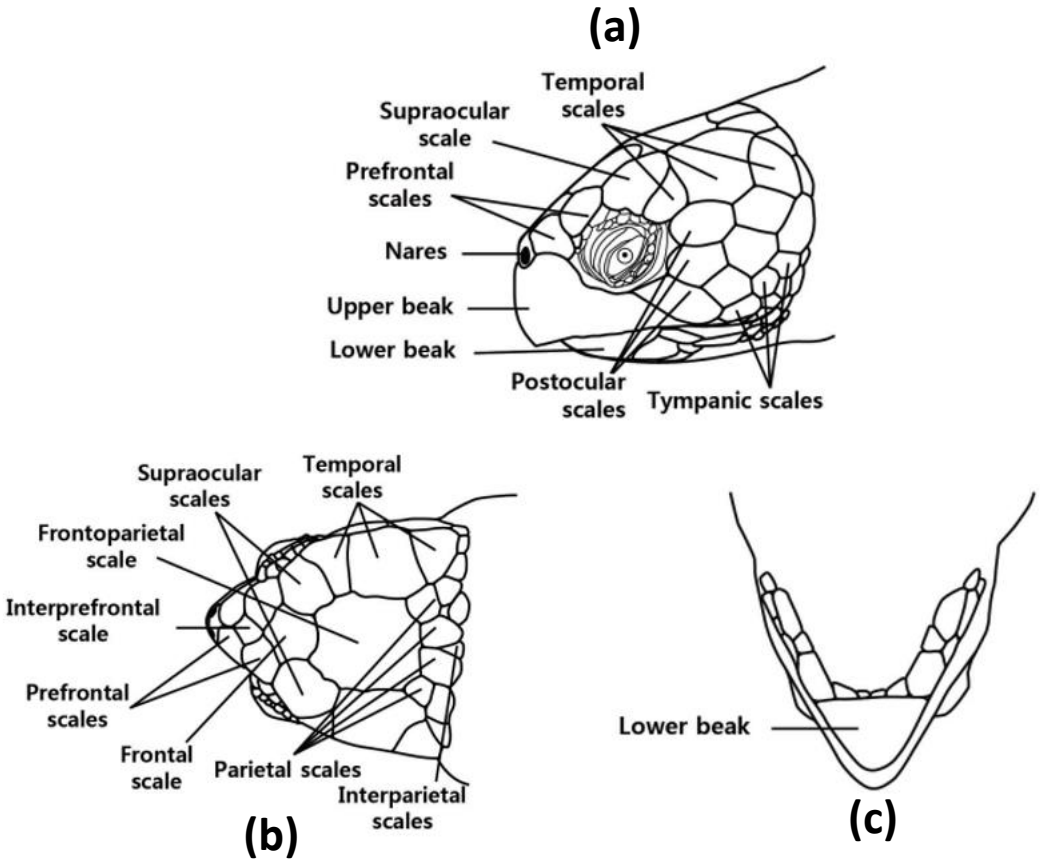

Figure 4: Morphological characteristics of the loggerhead turtle's head (Caretta *caretta*) left, dorsal and ventral view **(17)**

(a): Lateral view

(b): Dorsal view

(c): Ventral view

The dorsal and lateral head scales and the dorsal scales of the flippers are also reddish-brown, but with light to medium yellow margins. The unscaled areas of the integument (neck, shoulders, limb bases, inguinal area) are dull brown dorsally and light to medium yellow laterally and ventrally. The plastron is medium to light yellow, and the thick, bony carapace is covered by non-overlapping scutes that meet along seam lines. There usually are 11 or 12 pairs of **marginal** scutes, five pairs of **costals**, five **vertebrals**, and a **nuchal** (pre-central) scute that is in contact with the first pair of costal scutes.

Figure 5 illustrates the external morphology and scuttelation of the loggerhead turtle**.**

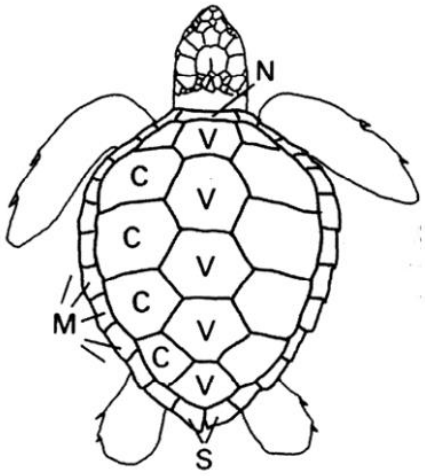

Figure 5: External morphology and scuttelation of *Caretta caretta***(16)**

v: vertebral scutes,

n: nuchal scutes

c: costal scutes,

m: marginal scutes,

s: supracodal scutes

The plastron is composed of paired **gular**, **humeral**, **pectoral**, **abdominal**, **femoral**, and **anal** scutes and connected to the carapace by three pairs of poreless **inframarginal** scutes **(13).**

Figure 6 illustrates the external morphological characteristics of the plastron of the loggerhead sea turtle.

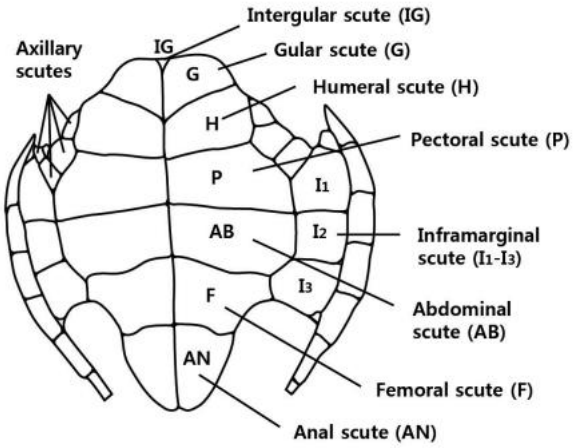

Figure 6: Morphological characteristics of the plastron of the loggerhead sea turtle **(17)**

Loggerhead's front flippers are used for agile maneuvering, they are relatively short compared to other species, Additionally, each front flipper is tipped with two strong claws **(15),** its flippers are chestnut brown, fading to yellow at the edges **(16).** The weight of *C.caretta* varies by location, reaching up to 180 kg in the western Atlantic, 150 kg in Australia, and under 100 kg in the Mediterranean **(15).**

I.2.3 Sexual differentiation

marine turtles, like many turtle species, lack heteromorphic sex chromosomes **(18)** So the direction of sexual differentiation of the embryo depends greatly on the temperature prevailing during incubation of the egg **(19)** loggerhead sea turtle eggs incubated at constant temperatures produce females at warmer and males at cooler temperatures **(20-22).** This phenomenon, known as temperature-dependent sex determination (TSD) highlights the influence of the environment on sea turtle development. **(18).** Therefore, identifying the sex of hatchlings and sub-adult loggerheads requires alternative methods such as blood hormonal dosage, histology and direct observation of gonadal morphology by laparoscopy or during necropsies **(23).**

Unlike sub-adults and hatchlings, adult sex ratio is commonly regarded as relatively easy to obtain because adults are sexually dimorphic. In particular, the most obvious characteristic is the large and muscular prehensile tail of adult males **(23)** also, adult

males would have a higher 'Plastron-Tip of Tail' to 'Cloaca-Tip of Tail' ratio than adult females **(24).** The distance from the cloaca to the posterior margin of the carapace appears to be the most effective measurement for sexing turtles **(25).** Figure 7 illustrates sex differentiation by tail length measurements.

Figure 7: Two tail length measurements **(26)**

a: Total tail length (TTL) is the distance from the midline of the posterior margin of the plastron to the end of the tail following the curvature of the tail.

b: Post-cloacal tail length (PTL) is the distance from mid-cloacal opening to the end of the tail following the curvature of the tail.

I.2.4 Age estimate

There are several techniques for determining the age of marine turtles, each with some difficulties in application and interpretation. The earliest estimates of age at size and age at first reproduction for wild sea turtles were provided using growth data from mark-recapture studies. This remains one of the most common approaches for estimating somatic growth rates, age at sexual maturation, and stage duration in sea turtles **(27). Skeletochronology** is a valuable tool for marine biologists studying sea turtles it is one of the most reliable indirect methods for estimating the age and growth rates of marine turtles **(27-29).**

it has been performed on the humerus bone because it has a higher proportion of compact (cortical) bone compared to spongy (cancellous) bone.

Also, the bone matrix in the humerus exhibits clear layering, making it easier to identify and interpret growth markers **(31-32)**. Despite the advantages of the humerus, the phalanges of *C.caretta* can be reliably used with similar accuracy for studying growth patterns **(33).** Researchers focus on identifying yearly lines of arrested growth (LAGs) in bones. These LAGs form annually during slower growth periods. The key challenge in skeletochronology lies in differentiating these annual LAGs from other non-annual marks on the bone that can be caused by a variety of factors such as illness, injury, or temporary fluctuations in growth rate **(34).** For sea turtles, annual periodicity of LAG has been demonstrated for C. caretta using vital fluorescent labelling **(35-36)** or known-age samples **(37)** On the other hand, by applying the back-calculation method **(38)** or the correction factor equation **(39),** it is possible to estimate the number of totally resorbed LAGs that must be added to the number of visible LAGs to obtain an accurate age estimation.

I.3. Biological characteristics

Loggerheads nest on ocean beaches and occasionally on estuarine shorelines loggerhead nesting beaches tend to be wide, sandy beaches backed by low dunes and fronted by a flat, sandy approach from the water **(40).** nests are typically laid between the high tide line and the dune front **(41).** Sea turtle egg development hinges upon a precisely regulated environment within the nest. This environment requires a high degree of humidity. Simultaneously, the substrate needs to be well-aerated, allowing for the developing embryos to exchange vital gases. also, the surrounding sand must maintain a specific temperature range optimal for proper egg development **(40).** On average, females lay between 100 and 130 eggs per clutch **(13).** Loggerhead nests typically incubate for approximately 49 to 73 days. The length of the incubation period is inversely related to nest temperature, such that between 26o C and 32o C, a change of 1o C adds or subtracts approximately 5 days **(42).** The warmer the sand surrounding the egg chamber, the faster the embryos develop **(22)**.

Loggerhead hatchlings take 4-7 days to emerge. They break free from their shells (pip) over 1-3 days, then dig out over 2-4 days **(43).** Hatchlings emerge from their nests en masse almost exclusively at night, and presumably using decreasing sand temperature as a cue **(44).**

Hatchlings first use light cues to find the ocean. On naturally lighted beaches without artificial lighting, ambient light from the open sky creates a relatively bright horizon compared to the dark silhouette of the dune and vegetation landward of the nest. This contrast guides the hatchlings to the ocean **(45).**

I.4. Feeding ecology

Loggerhead sea turtles are carnivorous that exhibit a generalist foraging strategy, their powerful jaws allow them to easily crush and eat jellyfish, crabs, a variety of mollusks and predominantly consuming benthic invertebrates across their geographic distribution. the list of the types of prey eaten by loggerheads in the wild is extensive. Benthic invertebrates were the predominant prey. Sea pens, crabs, and mollusks accounted for 94 % of the dry weight of the digestive tract samples of some investigated turtles **(46)**.

This remarkable adaptability in prey selection underscores the versatility of loggerhead foraging behavior, contrasting with the more specialized feeding tactics observed in other sea turtle species **(46).**

I.5. Multiple threats

All known threats to loggerheads were identified and characterized as part of the threats analysis process. according to **(47)** these identified threats have been grouped into seven functional categories:

I.5.1. Fisheries bycatch

Accidental entanglement in fishing gear targeting other species.

I.5.2. Resource use (non-fisheries)

including legal and illegal harvest and numerous other human activities that cause turtle mortality, such as vessel strikes.

I.5.3. Habitat loss and modification

Coastal development and shoreline stabilization projects destroy nesting and foraging grounds.

I.5.4. Ecosystem alteration

Overfishing and habitat alteration affecting food sources and overall ecosystem health.

I.5.5. Pollution

Artificial lights disorienting hatchlings, plastic debris causing ingestion, and oil spills harming health.

I.5.6. Species interactions

Both native and invasive species posing threats to eggs, hatchlings, and adult turtles.

I.5.7. Climate change and extreme weather events

Rising sea levels and storms impacting nesting beaches and overall survival.

I.6. Migration and habitat

Loggerhead turtles are widely distributed in the Mediterranean Sea **(48).** Juveniles have an oceanic distribution but move to **neritic habitats** before reaching sexual maturity, once mature, they regularly migrate between feeding grounds near the coast (neritic foraging sites) and nesting rookeries **(49).** The distribution of hatchlings and early juveniles is primarily attributed to passive drifting with the ocean's currents s **(50-53).**

The transition from passive to active swimming occurs when individuals reach a straight carapace length (SCL) of 40–60 cm **(49),** individuals of this size range or larger are competent swimmers that may exhibit strong homing behavior **(54,55).**

CHAPTER II: HISTORY OF SEA TURTLES STRANDINGS IN THE MEDITERRANEAN

II .1. Overviews

Strandings of deceased marine turtles and marine mammals offer valuable insights into sea mortality rates and potential causes of death, especially when fresh specimens allow for necropsy analysis **(56)**. However, these events vary significantly in location and time, typically representing a small portion (around 10-20%) of overall mortality. Factors like predators, scavengers, wind, and currents affect stranding frequency **(57-59)**, with fewer occurrences further from the coast. Estimating total sea turtle mortality only through stranding data is difficult, especially in offshore environments where carcasses may not drift ashore. Understanding mortality patterns, whether from natural causes or human activities, is crucial for effective conservation strategies for marine species listed on the IUCN Red List, facing threats like fisheries bycatch and exploitation leading to increased mortality rates **(60).**

II.2. Andalusian coast

Between 1997 and 2015, there were 2495 reported cases of sea turtle strandings along the Andalusian coastline. Among these recorded incidents, Loggerheads (*Caretta caretta*) accounted for 2311 (92.6%) and Leatherbacks (*Dermochelys coriacea*) for 175 (7.1%). Other species were documented but excluded from this study due to their statistically insignificant numbers: Green turtles (*Chelonia mydas*) with 6 cases (0.2%) and Kemp's ridley turtles (*Lepidochelys kempi*) with 3 cases (0.1%) **(61).**

For Loggerheads, there was noticeable interannual variability. The periods 1997-2000 and 2006-2009 could be considered as having low stranding rates. However, the periods 2001-2005 and 2010-2013 exhibited higher than average stranding numbers **(61)**. Figure 8 is a map showing the Andalusian coast.

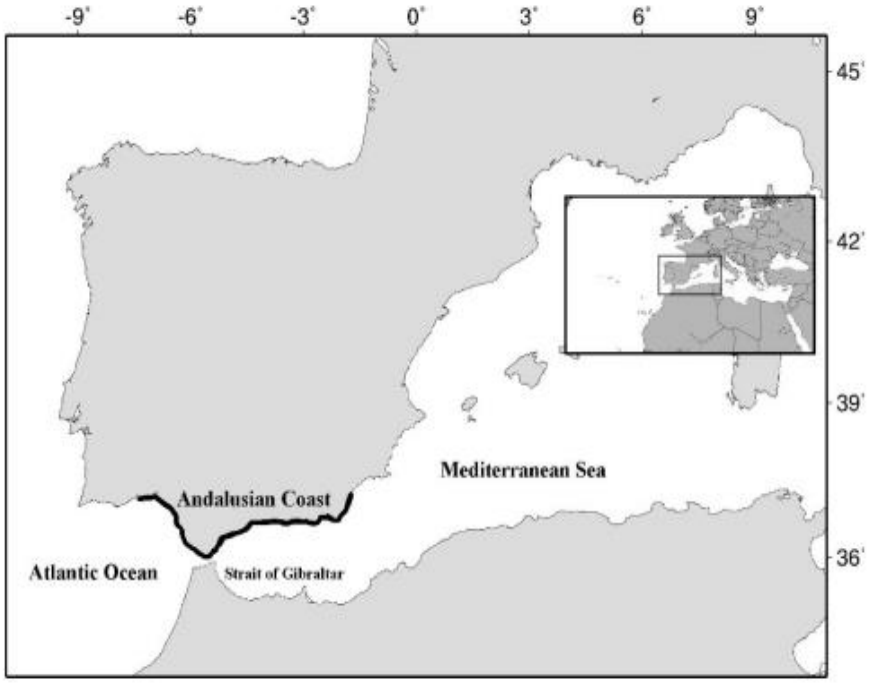

Figure 8: The Andalusian coast **(61)**

Figure 9 illustrates Inter-annual variability of Loggerhead strandings in the period 1997-2015.

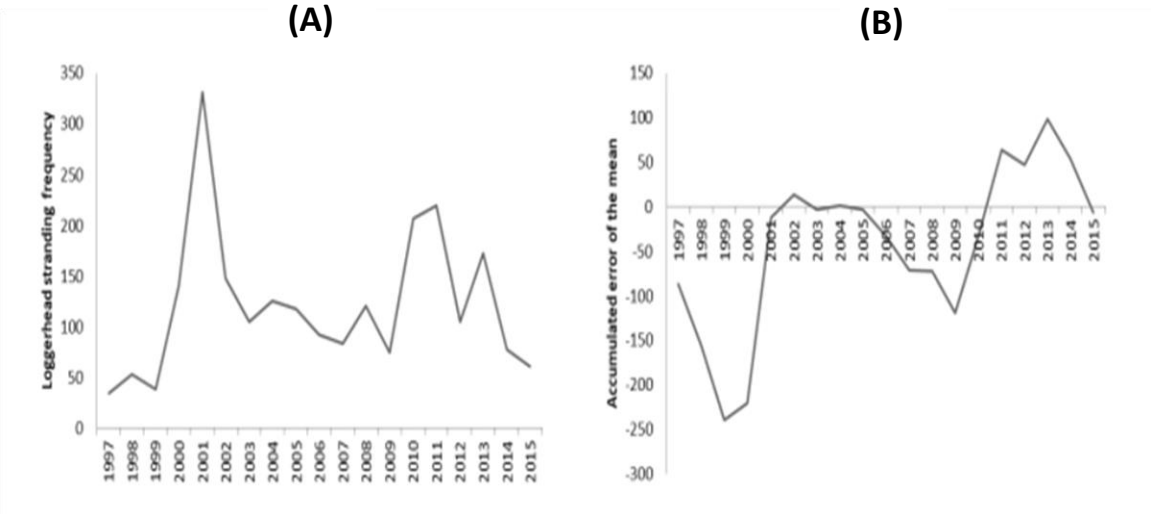

Figure 9: Inter-annual variability of Loggerhead strandings in the study period 1997-2015. **(61)**

(A) Loggerhead stranding frequency observed per year.

(B) Accumulated error of the mean Loggerhead strandings per year.

II.3. Turkey

From 2002 to 2017, a total of 302 stranded turtles were discovered on Samandağ Beach, located on the eastern Mediterranean coast of Turkey. Among these, 167 (55.4%) were green turtles and 127 (42%) were loggerhead turtles. Six individuals (2%) could not be identified. The average annual strandings were 10.5 individuals for green turtles, 7.9 individuals for loggerheads, and 18.75 for both species combined on Samandağ Beach **(62)**. The percentage distributions of stranded sea turtles across the years are depicted in figure 10.

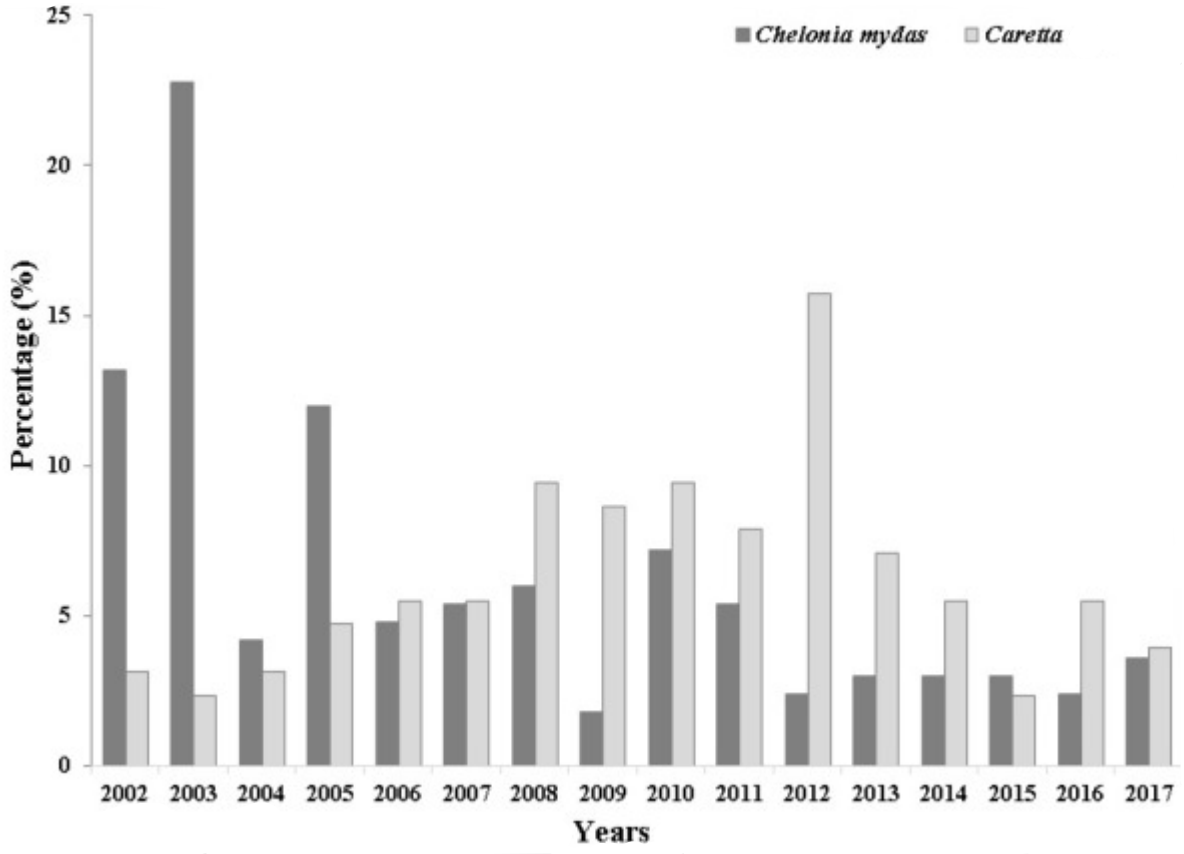

Figure 10: Yearly percentage of stranded *Caretta caretta* and *Chelonia mydas* individuals on Samandağ Beach between 2002 and 2017 **(62)**

The data regarding the number of stranded individuals indicates that both sea turtle species were frequently encountered on Samandağ Beach, Turkey. The period of sample collection, spanning from April to October, proved to be suitable for determining both the frequency of strandings and the causes of death. Similarly **(62).** noted that recordings of stranded loggerhead turtles were most prevalent between April and September along the Italian coasts of the Mediterranean from 1980 to 2008 **(62)**.

II.4. Italy

Italy is centrally located in the Mediterranean Sea and shares boundaries with significant foraging areas for loggerhead turtles in the region. These findings validate previous concerns regarding the extent of anthropogenic mortality in Italian waters. **(63)**. Data collection on stranded or floating sea turtles along the Italian coasts commenced in 1980 as part of a broader research and conservation initiative, since then, procedures have been refined, and coverage has expanded, facilitated by various independent teams that established dedicated stranding networks. Out of the 5983 records, only 0.8% were identified as species other than loggerhead turtles (*Caretta caretta*) along the Italian coast: 18 green turtles (*Chelonia mydas*) and 27 leatherback turtles (*Dermochelys coriacea*). Given the rarity of these species and the distinctive features of leatherback turtles compared to loggerhead turtles, the remaining 5938 records, where the species was either identified or unidentified, were considered as loggerhead turtles. These records were the focus of the subsequent analyses. Among these loggerhead turtles, 2375 were discovered stranded (of which 77.1% were deceased), 1494 were observed floating at sea (with 12.8% found dead), while the finding type for the remaining 2069 was unspecified. The spatial distribution of the stranding records and their density (turtles per kilometer) is presented in table 1.

Table 1: Distribution and density of stranding records along the coasts, per Italian administrative region and marine area **(63).**

Marine area	Region	Stranding records (*n*)	km	Turtles km^{-1}
North Tyrrhenian	Liguria	15	350	0.04
	Toscana	22	442	0.05
	Total	37	792	0.05
South Tyrrhenian	Lazio	14	290	0.05
	Campania	19	480	0.04
	Calabria	77	375	0.21
	Sicilia	76	597	0.13
	Total	186	2742	0.11
Sicily Channel	Sicilia	175	593	0.30
Ionian	Sicilia	65	273	0.24
	Calabria	116	405	0.29
	Basilicata	41	40	1.03
	Puglia	77	248	0.31
	Total	299	966	0.31
South Adriatic	Puglia	363	576	0.63
	Molise	9	36	0.25
	Abruzzo	10	125	0.08
	Total	382	737	0.52
North Adriatic	Marche	201	172	1.17
	Emilia-Romagna	1016	130	7.82
	Veneto	11	140	0.08
	Friuli-Venezia Giulia	54	111	0.49
	Total	1282	553	2.32

Between 2019 and 2021, a total of 255 stranding records were documented along the Italian coast, with 244 of them being recorded with carapace length (CCL) and other parameters outlined in the protocol. As anticipated, the predominant species encountered was the loggerhead sea turtle, *Caretta caretta* (n=254), with only one instance of a green sea turtle, *Chelonia mydas* (CCL=56 cm). Consequently, all subsequent analyses focused on loggerhead sea turtle strandings. The recovery of flipper tags was minimal (n=2), originating from Tunisia (n=1) and Italy (n=1).

The cause of death could be confidently determined for only a limited number of cases, including boat propeller strikes (n=15) and net entanglement (n=1). The remaining stranded sea turtles (n=228) showed no clear signs of external trauma, injury, infection, or parasites **(64)**.

II.5. Tunisia

Stranded animals offer a wealth of information regarding their biology and ecology. Since the launch of the National Stranding Network on marine turtles and cetaceans in 2004 along the entire Tunisian coast, a total of 278 stranded turtles have been examined, with 258 of these recorded along the coast of the Gulf of Gabes in South Tunisia. Loggerhead turtles comprised the majority of stranded turtles (96.76% of stranding data), while only four green turtles (1.43%) and two leatherback turtles (0.71%) were documented. the findings indicate that the majority of stranded turtles were juveniles (74.5%). The most commonly assigned causes of stranding were longline interactions (6%) and boat collisions (4%). Additionally, bottom trawling appears to have a significant impact on loggerhead turtles in the area, as suggested by stranding data **(65)**.

Between 2004 and 2007, a total of 278 stranded turtles were documented along the Tunisian coast. The predominant species among these was the loggerhead turtle, *Caretta caretta*, accounting for 96.76% of the recorded cases. loggerhead turtles are the dominant sea turtle species within Tunisian waters. This finding is further supported by the presence of nesting sites along specific Tunisian beaches **(65)**.

II.6. Morocco

Morocco boasts a strategic geographic position at the northwestern tip of the African continent renowned for its rich marine biodiversity, situated between the Mediterranean Sea and the Atlantic Ocean, boasting a coastline spanning over 3,500 kilometers. The Mediterranean coastline stretches for 512 kilometers, while the Atlantic coast extends for approximately 3,000 kilometers **(66)**. Over a span of twenty-four years (1998–2022), 208 sea turtles were documented along the coasts of northwest Morocco, Loggerheads constituted the overwhelming majority of reported strandings (n = 184; 88.47%), whereas leatherbacks accounted for only 10% of the records (n = 21). Approximately 1.44% of the records (n = 3) could not be identified. The vast majority of stranded turtles were found deceased (n = 205; 98.55%), with only three individuals discovered alive **(66)**.

II.7. Malta

The population in Malta appears unaffected by the Atlantic influence, as the waters are predominantly inhabited by individuals originating from the Mediterranean, with a significant contribution from nearby and sizable loggerhead colonies **(67)**.

Reports of *Caretta caretta* sightings in Malta are consistently frequent **(68)**. Strandings, accidental captures, and reported sightings indicate that this species is present year-round in Malta, with peak numbers typically occurring between June and September. This period coincides with the highest fishing activity which may explain the elevated reported numbers as most available information is derived from incidental captures. Balzan in Groombridge also notes that loggerhead turtles are often observed basking at the surface or beneath palm leaves used as fishing floats. This basking behavior is further confirmed through communication with sea-users who encounter relatively large groups of migrating turtles and/or basking on the sea surface during late spring and summer **(68)(69)**. The existing data on *Caretta caretta* primarily consists of observations and reports regarding sightings, as well as incidents of strandings and accidental captures by fisheries or instances of injured turtles. The latter category typically involves turtles collected for rehabilitation purposes **(70)**.

Table 2 displays the published data concerning sightings and strandings of loggerhead turtles.

Table 2: The published information regarding sightings and strandings of loggerhead turtles (1991-2001) **(71).**

Date	Number of turtles sighted	Indication of location of sighting	State
January 1991	1	off Gozo	Injured
January 1997	1	Bugibba	Dead
July 1997	1	Għajn Żejtuna	Alive
October 1997	1	Ix-Xlendi	
July 1998	30	12 miles off Southeastern coast of mainland Malta	Alive
August 1998	25	24 miles off Southeastern coast of Malta	Alive
September 1998	1	20 miles off Southeastern coast of Malta	Alive
September 1998	1	18 miles off Southeastern coast of Malta	Alive
October 1998	4	8 miles off Southeastern coast of Malta	Alive
October 1998	8	11 miles off Southeastern coast of Malta	Alive
October 1998	8	15 miles off Southeastern coast of Malta	Alive
December 1998	1	No data	Alive
May 1999	1	Xlendi (Gozo)	Dead
July 1999	6	24 miles off Southeastern coast of Malta	Alive
August 1999	4	20 miles off Southeastern coast of Malta	Alive
August 1999	2	5 miles off Gnejna (to the Northwest)	Alive
October 1999	1	Gozo	Alive
September 2000	1	Off eastern Gozo	Alive
February 2001	1	Pieta	Alive
April 2001	1	Ix-Xemxija	Dead
May 2001	1	Sliema	Dead
May 2001	1	IC-Cirkewwa	Alive
July 2001	1	Il-Gnejna	Alive
July 2001	1	Tas-Sliema	Alive
October 2001	1	Pembroke	Alive

Figure 11 illustrates the mapping of data pertaining to strandings and injured turtles compiled by the Malta Environment and Planning Authority from 2006 to 2013**.**

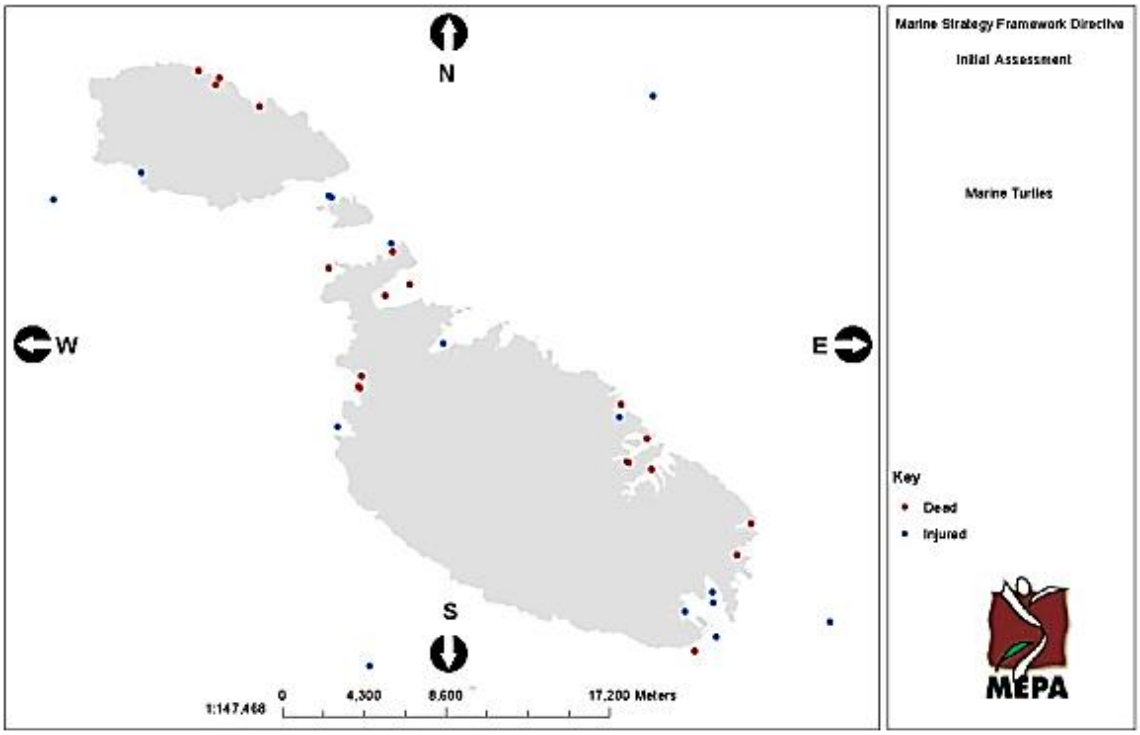

Figure 11: Data on strandings and injured turtles collated by the Malta Environment and Planning Authority during the period 2006-2013**(72).**

II.8. Algerian coast

Sea turtles have been consistently documented along the Algerian coast since the late 18th century, often involved in accidental or intentional strandings. Among these occurrences, 70% are loggerhead turtles (*Caretta caretta*),30% are leatherback turtles (*Dermochelys coriacea*), with sporadic sightings of the green turtle (*Chelonia mydas*) **(2).**

Since 2012, the Algerian authorities have included the three species of marine turtles (*Caretta caretta, Dermochelys coriacea,* and *Chelonia mydas*) in the list of protected animal species, as outlined in Executive Decree No. 12-235 dated May 24, 2012, which establishes the list of protected non-domestic animal species **(74)**.

In the context of the western Mediterranean, the Algerian-provincial basin stands out as the largest among its counterparts. Stretching over 1600 km, the Algerian coast represents approximately 3.4% of the total Mediterranean coastline. Data on recorded strandings from 2002 to 2020 indicate a total of 23 adult individuals (across all species), with *Caretta caretta* being the most prevalent species at 44%. The green turtle was only documented once between 2003 and 2020 **(75).**

Some studies were conducted along the Algerian coast, spanning from the far eastern point at Altaref to the far western point at Tlemcen. From December 2015 to December 2017, a total of 63 sea turtles were found stranded along the Algerian coastline **(73).** The loggerhead sea turtle (*Caretta caretta*) accounted for the highest number of strandings with 44 individuals (69.8%), followed by the leatherback (*Dermochelys coriacea*) with 18 individuals (28.6%), and the green turtle (*Chelonia mydas*) with one individual. Adult loggerhead turtles were more common among the stranded turtles, while late juveniles and adults were predominant among the leatherbacks. Loggerheads tended to strand more in the summer months (July and August), whereas leatherbacks were more commonly stranded during winter. The distribution of strandings showed a slight prevalence along the western and central shores for *C. caretta* and a clear dominance in the west for *D. coriacea*. The primary cause of death was determined for 50.8% of the stranded turtles, with incidental catch by artisanal fisheries and boat collisions being the main human-related causes for loggerhead strandings, while boat collisions were the primary cause for leatherback strandings **(73).**

Figure 12 illustrates the mapping of the distribution of stranding sea turtles along Algerian coast, the Western, Central and Eastern zone during 2016–2017 And table 3 displays the number of marine turtles strandings in 14 localities of the Algerian coast during 2016–2017

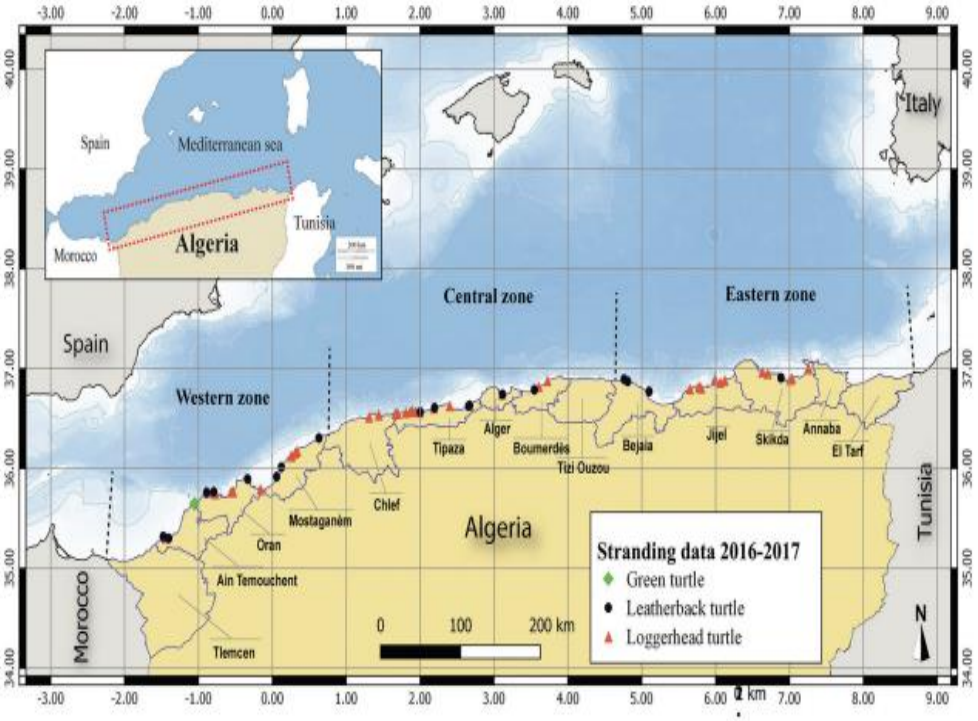

Figure 12 Map showing the Western, Central and Eastern zone, and the distribution of stranding sea turtles *Caretta caretta* (brown circle), *Dermochelys coriacea* (black circle) and *Chelonia mydas* (green circle) along Algerian coast (2016–2017) **(73).**

Table 3: Number of marine turtles strandings in 14 localities during 2016–2017 of the Algerian coast **(73).**

		Caretta caretta		*Dermochelys coriacea*		*Chelonia mydas*	
Area	**Locality**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
West	Tlemcen	–	–	–	–	–	–
Center	Ain temouchent	1	–	2	–	–	–
East	Oran	6	2	3	–	1	–
	Mostaganem	5	2	3	–	–	–
	Chlef	2	1	–	–	–	–
	Tipaza	8	2	2	1	–	–
	Algiers	1	1	–	1	–	–
	Boumerdese	–	1	–	1	–	–
	Tizi ouzou	–	–	–	–	–	–
	Bejaia	–	–	1	1	–	–
	Jijel	4	2	1	–	–	–
	Skikda	3	3	1	1	–	–
	Annaba	–	–	–	–	–	–
	Altarf	–	–	–	–	–	–
N		30	14	13	5	1	0

Data from 2019 to 2021 regarding recorded strandings reveal a total of 17 adult individuals (across all species) in table 4 with *Caretta caretta* being the predominant species, accounting for 76.47% of the total. **(2)**

Table 4: Distribution of strandings of the two species of sea turtles stranded since 2019 to date along the Algerian coast **(2)**

Wilaya	*Caretta caretta*	*Dermochelys coriacea*
Oran	0	1
Tipaza	7	0
Alger	1	2
Tizi Ouzou	1	0
Bejaia	1	0
Jijel	2	0
Skikda	1	0
El Tarf	1	0
Total	14	3

Tipaza province recorded the highest number of strandings, while the rest of the provinces had only a few strandings (table5). **(2)**

Table 5: Distribution of strandings of different species of marine turtles by wilaya since 2019 until 2021 **(2).**

Wilaya	*Caretta caretta* %	*Dermochelys coriacea* %
Oran	0 %	5.88 %
Tipaza	41.18 %	0 %
Alger	5.88 %	11.76%
Tizi Ouzou	5.88 %	0 %
Bejaia	5.88 %	0 %
Jijel	11.76 %	0 %
Skikda	5.88 %	0 %
El Tarf	5.88 %	0 %
Total	82.34 %	17.64 %

Experimental part

CHAPTER III: Investigative Procedures

III .1. Objectives

Our study aims to conduct an investigation into the strandings of *Caretta caretta* (loggerhead sea turtles) in order to determine their precise causes and contributing factors. this investigation will provide a deeper understanding of the threats facing these animals. In order to reach these objectives, we have divided our experimental part into two parts.

First part by analyzing data collected on stranded turtles along the Algerian coastline, the other part where we seek to identify the mechanisms that lead to these deaths by performing an external examination to understand the environmental or anthropogenic elements that contribute to them.

This knowledge of the causes of strandings will make it possible to implement more effective conservation measures to protect this threatened species.

III .2. Presentation of the study area

Algeria's coastline stretches for approximately 2,148 kilometers (1,335 miles) along the Mediterranean Sea, it boasts the title of North Africa's longest **(76)**. The western part of the coastline is dominated by sandy beaches, while the eastern part is more rugged and mountainous. it serves as a critical habitat for a diverse assemblage of marine fauna, including fish, dolphins, and sea turtles. It is home to diverse marine ecosystems and a rich biodiversity.

Along the Algerian coastline, Algiers, Boumerdes, and Tipasa offer challenges and opportunities for marine turtle conservation. Algiers, the bustling capital where urban development can encroach on nesting beaches. Boumerdes, with its mix of sandy stretches and rocky outcrops, provides diverse habitat but might face increased pressure from tourism. Tipasa, known for its historical ruins bordering the sea, offers a potential for integrating cultural preservation with marine turtle protection. Understanding the specific threats and opportunities in each of these locations is crucial for developing targeted conservation strategies that safeguard the sea turtles **(77-78).** Figure 13 shows a map of the studied area.

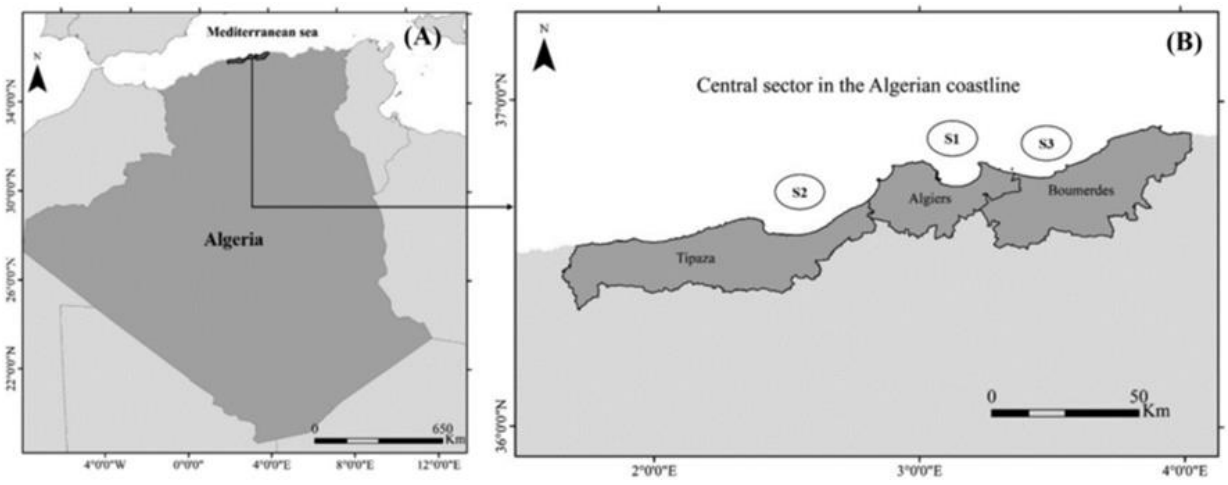

Figure 13: Map of the algerian coastline showing the localization of the studied region **(79)**

(A): Map showing a geospatial overview of algeria

(B): A detailed view of the central algerian coastline:

III .3. Material and methods

❖ III .3.1. On the spot

We adopted a diverse methodological approach focusing on several key areas:

III .3.1.1. Meetings and Interviews

Visits were conducted to the three cities (Algiers, Boumerdes and Tipasa) The goal was to establish direct contact with:

- **Marine Ecology Associations** Meetings were organized with members of local associations working for the protection of the marine environment. Their knowledge and experience were invaluable in better understanding the issues and challenges related to marine ecology in Algeria.
- **Fishers** Interviews were conducted with both artisanal and professional fishermen to gather their observations and concerns about stranded marine turtles.

- **Maritime Sector Stakeholders** Discussions were held with maritime professionals such as sailors to obtain a broader perspective on the state of marine turtle's activity.

III .3.1.2. Social Networks

- **Using Online Platforms:** Active monitoring was conducted on social media platforms, particularly Facebook to identify and analyze discussions, initiatives, and concerns about the stranded loggerhead turtles.
- **Contact with associations and Engaged Groups:** Contacts were established with online groups, and communities actively involved in the field of marine environment, allowing for the collection of additional information.

III .3.1.3. Documentary Data Collection

- **Consultation of Official Sources:** Official documents such as government reports, scientific publications, and environmental impact studies were consulted to obtain reliable and up-to-date data.
- **Analysis of Press Articles and Media:** Press articles, reports, and documentaries addressing marine ecology in Algeria were monitored to understand public perception and media attention related to this topic.

By combining these different approaches, the objective was to gather diverse information about the stranded marine turtles and find solutions and recommendations for its preservation.

❖ III .3.2. In the laboratory

Following data collection and contact with experts in the marine field, the decision was made to conduct identification, sexing, and further examination on two stranded sea turtles. These procedures were performed at the institute's laboratory.

- **Identification:** it is based on specific morphological criteria, such as carapace shape, size, and scute arrangement.
- **Sexing:** The sex of the sea turtles is determined by examining the external genitalia, considering the anatomical characteristics specific to each sex.
- **Buccal exploration:** this examination was performed on the sea turtles to analyze the condition of their buccal cavity and identify any potential pathologies that could explain their death.

The primary objective of this effort was to determine the cause of the sea turtle strandings.

III.4. RESULTS

❖ III.4.1. On the spot

In the course of our ongoing investigation efforts, we received a call on February 10th, 2024, from a scuba diving center in Ain-benian, Algiers. They alerted us to the discovery of two stranded marine turtles at "La Madrague" beach.

As in Figure 14, the initial scene revealed the stranded turtles on the beach. For further reference, Figure 15 provides a map pinpointing the exact location of the stranded turtles at "La Madrague." And figure 16 depicts the beach area where the turtles were found.

Figure 14 : The stranded sea turtles at Ain-benian (Algiers) **(personal picture)**

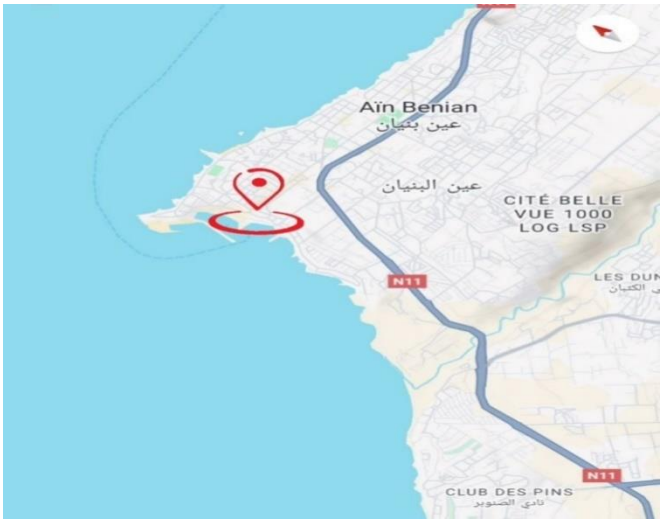

Figure 15: Map showing the location of the stranded turtles **(80)**

Figure 16: La Madrague beach, Algiers, Algeria: Site of stranded Sea Turtles **(personal picture)**

We carefully collected these animals for further examination. aiming to determine the cause of death and contribute to the understanding of threats faced by marine turtles in our region.

It is important to note that despite efforts, no stranded turtles were identified in Boumerdes during this period. This lack of reported strandings in the Boumerdes region could be due to a few factors, such as the limited information available on interactions between sea turtles and fishing gear in the area.

In the course of our data collection efforts, we opted for an innovative approach to reach out to fishers in Tipaza. Opting for a social media outreach strategy facilitated communication and data exchange. Furthermore, in May 2024, the survey revealed a concerning number of stranded marine turtles. We identified a total of five deceased animals scattered across various locations within the region, including Damous, Gouraya, and Larhat. As Figure 17 shows one of the stranded turtles at Damous (Tipasa).

Figure 17: One of the stranded loggerhead turtles of Tipasa **(personal picture)**

Table 6 presents a breakdown of the results we obtained during the approach.

Table 6 : Results of the number of the stranded sea turtles in the studied area

City	N: Sea turtles
Algiers	**2**
Tipasa	**5**
Boumerdes	**0**
Total	**7**

❖ III.4 .2. In the laboratory

The two stranded marine turtles we recovered in Algiers were transported to the laboratory for further examination. This examination likely included an external examination, a buccal examination to determine the cause of death, and analyses of the morphological characteristics to identify the exact species.

- **Species identification:**

  Through analysis of their anatomical features, the turtles were confirmed to be loggerhead sea turtles (*Caretta caretta*). This identification was based on key characteristics such as the inter-prefrontal scale on their large heads and the arrangement of five costal scutes on each side on their carapace.

- **Sex determination:**

  it relied on examining tail morphology. Female loggerheads possess short, slender tails, while males exhibit longer, thicker tails with their cloaca positioned closer to the tip. By using this method, the examination revealed that both stranded loggerheads were females.

- **Examination results:**

  - **External examination:** An external examination was conducted on both loggerheads. This initial assessment revealed a significant carapace fracture that was present in one of the turtles as figure 18 shows, suggesting a potential blunt force trauma event as the cause of death.

Boat strikes are a documented threat to sea turtles in the Mediterranean, and this injury strongly aligns with such an encounter.

Figure 18: The carapace fracture that was present in one of the turtles **(personal picture)**

- **Buccal exploration:** Instead of performing necropsies, we opted for a targeted approach by conducting incisions and buccal explorations including the tongue, palate, and pharynx, to gather information about potential ingestion of foreign objects. The Incision and buccal exploration revealed a discovery within the animal's respiratory system. A plastic bag was found lodged within the larynx. This foreign object likely mimicked the appearance and texture of a jellyfish, a common prey item for loggerhead sea turtles. It is hypothesized that, mistaking the plastic bag for food, the turtle ingested it, leading to a fatal obstruction. The plastic bag would have prevented the turtle from properly breathing, resulting in suffocation and death.

III.5. DISCUSSION:

In a humble contribution to a topical world issue, and in the course of several trips to the seaside, we recorded seven specimens of marine turtles in the central part of our coastline, five among them more precisely in Tipasa's coastal towns (Gouraya, Larhat, and Damous).

In addition, two females were found stranded in a beach nearby Ain Benian in Algiers. However, our investigations did not reveal any turtles at Boumerdes. It is crucial to stress that the presence of marine turtles on our coasts is an indicator of the richness of our ecosystem. This calls for a major mobilisation to protect these vital species, ensure their survival and preserve the biodiversity of our coastline. It is also an excellent opportunity to educate the general public about the importance of preserving these marine animals and their natural habitat.

the stranded species found in the area were able to be identified. The stranded species found were identified as *Caretta caretta* loggerheads. This result confirms not only the research carried out in 2021 by Benounnas and Tifoura **(2)** but above all the work of ALAE and his colleagues published in the Austrian journal Herpetozoa in 2019 **(2).** The two turtles collected in Algiers were studied, and in addition to determining their species, we tried to determine their sex. Indeed, the soft tail and long plastrons led us to assert that our loggerheads were female. This method was use by Lee et al in 2014 to determine the sex of loggerhead sea turtles in the Yellow Sea in Korea **(17).**

Finally, with carrying out a buccal examination, we were able to remove plastic from one of the turtle's tracheae and we noted injuries. Indeed, examination of our two turtles confirmed that they had been stranded as a result of ingesting plastic bags, and we observed injuries on their shells that were probably caused by trawlers or marine gear.

Conclusion

According to the modest study that we have carried out, it seems likely that the loggerheads *Caretta caretta* on the algerian coast originated in the Atlantic, as mentioned in almost all the studies carried out on these marine reptiles around the Mediterranean. It also appears that these chelonians migrate naturally towards the eastern Mediterranean, carried by the main sea currents, in search of suitable spawning grounds, in particular fine sand for their eggs. Our research shows that these animals, which are an important link in the trophic chain, are facing proven anthropogenic threats, especially marine pollution (sea which is polluted with oil and plastic). The present study cannot provide detailed information on the main causes of mortality other than fishing or collisions with boats. This is due to the small number of necropsies and the lack of information on interactions with fishing gear.

Regarding the status of loggerhead turtles on the coast we studied, our investigation shows a significant presence of this species. Furthermore, this species also suffers from human interaction. This work teaches us that there is an urgent and crucial need to act together to reduce the pollution and dangers that threaten these creatures. Together we can make a real difference by adopting environmentally friendly behaviors and raising awareness of the importance of marine conservation.

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