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Barcelona Convention

SPA/RAC
The Mediterranean Biodiversity Centre

MARINE TURTLE RESEARCH AND CONSERVATION IN LIBYA

A CONTRIBUTION TO SAFEGUARDING MEDITERRANEAN BIODIVERSITY

LIB STP

MAVA
FONDATION POUR LA NATURE

Mediterranean Action Plan
Specially Protected Areas Regional Activity Centre
Boulevard du Leader Yasser Arafat
B.P.337 - 1080 Tunis Cedex – TUNISIA
car-asp@spa-rac.org

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Marine Turtle Research and Conservation in Libya

A contribution to safeguarding Mediterranean Biodiversity

Study required and financed by:
Specially Protected Areas Regional Activity Centre (SPA/RAC)
Boulevard du Leader Yasser Arafat
B.P. 337
1080 Tunis Cedex - Tunisia
car-asp@spa-rac.org

LibSTP HQ Team

Abdulmaula Hamza (2005-2008, 2015), Almokhtar Saied (2006-2019), Esam Bourass (2005-2010), Ashraf Glidan (2008-2019)
Murad Sula (2005-2019), Mohamed Alsharif (2005), Mohamed ELGMEZI (2005), Ali Berbash (2009, 2017-19),
Usama Shalouf (2005), Mustafa Almuntasri (2017-2019), Khaled Dofani (2006-2007), Abdulmaola Beshyah (2006-2007),
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Elmaki Elagil (2009-10, 2017-19),

EGA media team

Mohamed Alrameh (2009-10, 2017-19) Ahmed Shaheen (2017-19) Abdulkarim Alharari (2017-19)

LibSTP Sirte Team

Salih Diryaq (2005-2019), (2007-2018), Hamad AbdAlla (2006-2018), Muftah Elsweede (2006-07),
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Abdelrahman Tbiqa (2006-2010), Ali Daiab (2010, 2018-19), Mohammed Albarq (2009-10), Salem Muftah (2009-10)
Abdalhalem Alshatir (Media, 2006-2010), Hussein Meftah (Media, 2006-2010).

LibSTP Misurata Team

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Ramdan Haloob (2006-10), Rabeea Abouzeed (2009-10), Ali Swalem (2008), Salih Beake (2006-10).

LibSTP Tobruk Team

Ismael Sakran (2008-2010), Idris Abdulla (2008-10), Salih Ali (2008-10), Kamal Belrahal (2008-10), Muftah hamad (2008-10),
Ahmed Mahmoud (2008-10).

LibSTP Benghazi Team

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Walid Alhelali (2018-19), Salah Alhadad (2009-10).

LibSTP Aljabal Alakhdar Team

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Fathalla Shaqluf (2008-2010, 2017).

Marine Biology Research Centre

Hisham El-Ghmati (2005), Dau Haddoud (2005), Abdalla A. Elmansori (2006), Mohamed shwehdi (2005)
Abdulbasset Abuissa (2007), Ehab Alsharif (2007) .

LibSTP Libyan partner teams

Bado Society

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The Libyan Organization for Conservation of Nature

Abd Alati Elswowayeb (2018-19), Huseen Salem (2018-19), Abdulmunem Albaour (2017-18).

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LibSTP International partners

- Atef Ouerghi (Regional Activities Centre for Specially Protected Areas - Tunisia)
- Lobna Ben Nakhla (Regional Activities Centre for Specially Protected Areas - Tunisia)
- Imed Jribi (University of Sfax - Tunisia)
- Flegra Bentivegna (Stazione Zoologica Anton Dohrn - Italy)
- Sandra Hochscheid (Stazione Zoologica Anton Dohrn - Italy)
- Fulvio Maffucci (Stazione Zoologica Anton Dohrn - Italy)
- Andreas Demetropolis (Cyprus Wildlife Society - Cyprus)
- Luis Cardona (University of Barcelona- Spain)
- Carlos Carreras (University of Barcelona - Spain)
- Yakup Kaska (Pamukkale University - Turkey)

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FOREWORD

As a Contracting Party to the Barcelona Convention, Libya has adopted the regional Action for the conservation of marine turtles in the Mediterranean since 1989 and started its implementation by identifying nesting beaches and assessing the nesting trends in a three-phase survey in 1995. It consisted of single beach surveys, meaning the beaches were inspected once for signs of turtles (tracks, nests, stranded specimens).

Data from this project was vital as Libyan beaches were speculated to host a large proportion of Mediterranean loggerhead turtles and the surveys confirmed that nesting occurs along the Libyan coast and identified nesting beaches that need to be further systematically monitored to increase knowledge on marine turtles nesting in Libya and to afford appropriate protection for the species and their habitats.

Since then, the Environmental General Authority (EGA)[1] started, thanks to the assistance of the Regional Activity Centre for Specially Protected Areas (SPA/RAC), an ambitious conservation programme of marine turtles in Libya, including the Capacity building of national and local actors, monitoring and research actions, to know more about the nesting of marine turtles and their critical habitats.

With the establishment of a dedicated national programme, the Libyan Sea turtle programme (LibSTP), more specific research and monitoring programmes were conducted in collaboration with SPA/RAC, the Stazione Zoologica Anton Dohrn (SZN) Italy), the faculty of Sfax (FS-Tunisia) with particular emphasis on migration routes to and from the Libyan coast, genetic structure, and the sex ratio of the Libyan population.

Furthermore, EGA joined the MAVA funded project and coordinated by SPA/RAC “Conservation of marine turtles in the Mediterranean” since 2017, where a national systematic monitoring scheme has been set up to monitor the Libyan coastlines accompanied by research and awareness activities.

This project has also supported the update of the National Action Plan for the conservation of marine turtles in the Mediterranean and the publication of this report.

Therefore, I would like to thank the Regional Activity Centre for Specially Protected Areas and Biological Diversity and its partners for their continuous support to make the Libyan programme for the conservation of marine turtles a successful conservation story.

The greatest credit goes to EGA staff in the headquarters and all coastal branches, who have kept in a truly exemplary manner the programme contributing each year to the regional efforts of understanding and protecting such highly migratory species.

Mr. Ali Alkekli

MAP Focal Point

[1] The Ministry of the Environment was established in 2021 in Libya, replacing the EGA.

The Environment General Authority (EGA) Establishment is an important step in environment protection in Libya. Since 2000, EGA managed to sustain environmental resources and reduce the pressure, particularly on the marine environment, by elaborating and implementing national strategies and action plans.

The marine coast of Libya, one of the longest coasts with more than 2000km, is one of the Mediterranean hotspots with thousands of vulnerable and threatened species and habitats. It is under increasing pressure resulting from various human activities and pollution. In this context, with its departments and branches, EGA is committed to protecting this biodiversity to fulfil national, regional, and global obligations.

Being Party to the Barcelona Convention and contributing to the conservation of the Mediterranean sea and its biodiversity, collaboration with other Parties and regional Partners is vital for the coordination of efforts to ensure conservation and sustainable management of the marine and coastal biodiversity components of the Mediterranean

In this context, the Libyan Seaturtle programme was born in 2005 on the beaches of Sirte. It aims to protect and preserve this species.

Thanks mainly to the Specially Protected Areas Regional Activity Centre (SPA/RAC) technical support, it was the first nucleus for a national team training at national and international levels.

The work has continued with nesting activity monitoring, accompanied by several conservation activities and scientific research, including studying the migration routes through satellite tracking, the sex-ratio, genetic analysis, and tagging.

The publication of this book, which will be one of the most important references on sea turtles in Libya, results from national commitment and international cooperation.

Mr. ElMaki Ayad Elagil

Director of the
Nature Conservation Department

Since mid-1980, the Contracting Parties to the Barcelona Convention included among their priority targets the protection of Mediterranean marine turtles (Genoa Declaration, September 1985). Indeed, these species are subject to high pressure from human activities and encounter various threats, including mortality in fishing gears and loss of vital habitats on land (nesting beaches). This led to the adoption in 1989 of the Action Plan for the Conservation of Mediterranean Marine Turtles.

Although they do not have a binding legal character, these action plans have been adopted by the Contracting Parties as a Strategic regional framework setting priorities and activities to be undertaken. They call for greater solidarity between the States of the region and for better effort coordination to protect marine turtles as a migratory species that requires efforts extending beyond national borders. This approach has been proved to be necessary to ensure conservation and sustainable management of the concerned species in every Mediterranean area of their distribution.

The Marine Turtle regional Action Plan, as all other regional Action Plans established within the UNEP/MAP context, is evaluated and updated every five years and submitted to the official meetings of the National Focal Points for the Specially Protected Areas and Biological Diversity (SPA/BD) for their consideration and to the Conferences of the Parties to the Barcelona Convention (COPs) for its final adoption.

SPA/RAC was entrusted to assist the Mediterranean countries to fulfil their commitments to implement the Action Plan provision at regional and national levels.

Here is an inspiring conservation story that proves what is possible when we work together and join efforts and means.

Mr. Khalil ATTIA

SPA/RAC Director

General Introduction

The Environmental General Authority - Libyan Sea Turtle Programme (EGA-LibSTP): A conservation success story we can celebrate in 2021.

By Lobna Ben Nakhla and Atef OUERGHI

It is easy to feel hopeless when reading the news coverage of ocean conservation. Between climate change, acidification, pollution, invasive species, marine litter and overfishing, it often feels like the ocean and its biodiversity, which we rely on, will soon be lost.

Nevertheless, there is always hope. There are successes in ocean conservation, and they often occur when small groups of people fix problems in their communities. Whether beach cleanup, hanging lights on fishing nets to prevent turtle entanglement or working with local authorities to prevent seagrass meadows loss, natural solutions can make a difference in protecting the ocean.

The year 2020 and 2021 hit the globe with bad news one after the other, causing much despair. However, we can celebrate some conservation success stories: The Libyan Sea turtle Programme (LibSTP) of the Environmental General Authority.

The LibSTP success story is among the long list of achievements of the Regional Action Plan for the conservation of marine turtles in the Mediterranean and shows the importance of establishing such an Action Plan for the marine turtles in the region. Although all Action plans do not have a binding legal character, the Contracting Parties adopted the Barcelona Convention's action plans as regional strategies setting priorities and activities to be undertaken. They call for greater solidarity between the States of the region and coordinate efforts to protect this species. This approach has been proved to be necessary to ensure conservation and sustainable management of the concerned species in every Mediterranean area of their distribution.

The story of the LibSTP could be divided into three phases, fitting in three periods of the evolution of the regional Action Plan for the conservation of marine turtles in the Mediterranean:

The first phase between 1989 and 1999:

The adoption of the first version of the regional Action Plan was a response to understanding marine turtles and their biology and conservation needs. Marine turtles in the region were relatively unknown and unconfirmed.

In Libya, the nesting of marine turtles was almost unknown until a three-phase survey was launched in 1995. It consisted of single beach surveys, meaning the beaches were inspected once for signs of turtles (tracks, nests, stranded specimens). The project was organized by the Regional Activity Centre for Specially Protected Areas (SPA/RAC, United Nations Environment Programme (UNEP)/MAP) and funded by, in alphabetical order, the Marine Biology Reserve Centre (Tajura, Libya), MEDASSET, the Technical Centre for Environmental Protection (now the Environment General Authority), the SPA/RAC and the Worldwide Fund for Nature (WWF International Mediterranean Programme). The 1995 survey results, carried out in June and July, found 342 total crawl tracks of nesting females and 176 nests, which were present on most of the prospected beaches. Data from this project was vital as Libyan beaches were thought to host a large proportion of Mediterranean loggerhead turtles, but the lack of data from this Mediterranean nation made species conservation efforts difficult. The project confirmed that nesting occurs along the Libyan coast and identified nesting beaches that need to be systematically further monitored to increase knowledge on marine turtles nesting in Libya and to afford protection for the species and these habitats.

Assistance has been provided to the countries every year in Capacity-Building through scientists' support, nominated by the countries, to attend training courses in Conservation Techniques and Beach Management held at the Lara Reserve, Cyprus (these are 10 day, hands-on courses). Several participants from Libya trained at this important training to learn about survey methods, monitoring and other research aspects at the identified nesting beaches.

The second phase between 1999 and 2006

Where knowledge and dissemination of information on marine turtles have been rapidly increasing, made it mandatory to frequently revise conservation plans and programmes if they are to stay abreast and take advantage of current knowledge. An updated Mediterranean Marine Turtle Action Plan was adopted to continue improving knowledge through research, monitoring and protection, conservation and managing marine turtle populations and their habitats, primarily focusing on Chelonia mydas. The Action Plan also included a priority list for each country. For Libya, the priorities were to further study the nesting population dimension and nesting distribution along the coasts and assess coastal fisheries' impact on marine turtles.

In 2003, Libya was among the first Mediterranean countries to establish a first national action plan for marine turtles within the framework of elaborating the Strategic Action Programme for the conservation of Biological Diversity (SAP BIO) in the Mediterranean Region.

In 2004, researchers of the Libyan Marine Biology Research Centre surveyed 26 km of beaches on Libya's eastern coast and identified eight new nesting beaches, recording 15 loggerhead crawls of which eight resulted in nests.

In 2005, as an initiative to implement the National Action Plan for the conservation of sea turtles and their habitat, the LibSTP was officially launched by the Environment General Authority (EGA) of Libya; the goal is to study, protect and to raise awareness about Mediterranean Sea turtles in Libya (chapter I). In addition, the Programme trains turtle enthusiasts and students to survey and protect nesting beaches voluntarily. Surveys in 2005-2008 indicated that nesting is primarily concentrated mainly in four areas: the Gulf of Sirte, the region around Benghazi, some sandy beaches of Aljabal Alakhdar (Cyrenaica) and the region of Derna-Tubrok. In 2005, 73 nests were protected on three beaches west of Sirte, and 3,179 hatchlings were successfully released. Five hundred 50 nests were recorded in 2006, and 841 were documented in 2007 on 28 beaches along the Libyan coast.

The nesting situation in Libya is now more apparent, and conservation activities have been developed; a comprehensive picture of nesting in the country was presented during the two Mediterranean Conferences on Marine Turtles (in Rome 2001 and Kemer- Turkey 2005), and in 2006 the International Sea Turtle Symposium (ISTS) was held in the Mediterranean for the first time (Crete, Greece).

The third phase between 2007 and 2012:

In this phase, several significant changes were made to the Mediterranean Action Plan. These include the Implementation Timetable for actions and the request that countries should prepare their own National Action Plans for the conservation of turtles and regularly report on implementing the Action Plan.

Global warming poses a potential threat to biodiversity all over the world. A group of species at particular risk are long-lived reptile species with temperature-dependent sex-determination. In these species, temperature increases can lead to biased sex ratios. Shortage of one sex is then expected to lead to mate-finding difficulties, failure to reproduce, and ultimately population decline. This can be seen as a mate finding Allee effect. The persistence of these species will depend on whether they can adapt their sex-determination system rapidly enough with increasing temperatures to prevent extinction. In other words, such species may require evolutionary rescue to persist. An investigation of the trends of sex-ratio of hatchlings in the most important nesting sites of Libya (chapter II) started on the beaches of Sirte in 2009 and Musratah in 2010. However, unfortunately, the study in Musratah could not be completed because of the war during the Libyan revolution.

Foraging areas are getting better known, though more work is needed to identify all the species' key areas. Migration key passages are now being studied through satellite tracking and other observation, though more data are needed to understand routes and identify critical passages. LibSTP undertook several satellites tracking exercises for nesting female turtles to contribute to the global understanding of their movements and identify critical areas of the marine turtles in the Mediterranean (chapter III), thanks to the collaboration with the Stazione Zoologica Anton Dohrn of Napoli (SZN) to detect the marine areas frequented by Libyan turtles for foraging and overwintering and to elucidate the spatial and temporal existence of migratory corridors that connect these habitats.

Key issues such as the genetic structure of the turtles in the Mediterranean and the degree of their isolation from the Atlantic populations is now a little better understood, though questions persist. Using nucleic and mitochondrial DNA (nDNA and mDNA) work, covering the paternal and maternal genetic makeup of turtles in the Mediterranean has brought up new issues and has diversified information. The LibSTP undertook the genetic characterization of the Libyan loggerhead turtle nesting population with the aims of defining the level of genetic differentiation and demographic autonomy of the Libyan nesting aggregation regarding the other Mediterranean populations; to improve our understanding of the colonization history of the Mediterranean Sea and to investigate the spatial distribution of Libyan individuals among different developmental and foraging grounds. This study filled an important gap in our knowledge of the loggerhead turtle population structure in the Mediterranean Sea, demonstrating that Libya hosts an important and unique loggerhead turtle management unit. Protecting this assemblage is fundamental for the conservation of the Mediterranean stock (chapter IV).

LibSTP's programme, besides patrolling some of the nesting beaches, also raised awareness through national media (chapter 5) and improved the previously unsuccessful tagging of sea turtles by switching from plastic to Inconel metal flipper tags (tag series LY0001-1000).

The fourth phase between 2013 and 2019

Since 2011, the fieldwork slowed down due to geopolitical instability and budget constraints.

However, the LibSTP's programme was represented during the 23rd International Seaturtle Symposium and the Fifth Mediterranean conference on Marine turtles conservation, held on 19-23 April 2015 in Dalaman, Turkey where over 120 paintings and artworks made by Sirte primary school students were on display in the conference venue's main hall. Furthermore, the programme team presented a short documentary titled A message of Hope (Chapter 5).

Based on its items- Demography of marine turtles nesting in the Mediterranean Sea: a gap analysis and research priorities, the fifth conference recommended establishing a new project for loggerheads in Libya, including the running of a beach monitoring programme, satellite tracking, stranding network establishment and bycatch data collection.

In 2017, Libya was among the beneficiary countries of the regional project implemented by SPA/RAC and its partners and financed by the MAVA foundation within its Outcome Action Plan M7: Human-induced direct mortality species minimized or eliminated at the Mediterranean level.

The project was an opportunity to revitalize the LibSTP programme as it aimed to support the establishment of monitoring networks, tools, and a sustainable management plan for marine turtles and their habitats in the Mediterranean. This is achieved by implementing harmonized monitoring protocols in line with the Ecosystem Approach (EcAp) guidelines and adopting a participatory and integrated approach that considers both local socio-economic and environmental contexts.

EGA, through the LiSTP programme team, joined the project in 2017 and set up a detailed work plan to implement the national component of the project in Libya, monitoring was re-established and intensified at known nesting sites (monitoring of nests temperatures for sex ratio, collection of genetic samples for molecular studies, beach quality including temperature, sand quality, threats, pressures, epibionts…etc.). Public Awareness and outreach activities have also been carried out.

The data collected by LibSTP within the MAVA project in Libya was presented during the 6th Mediterranean conference for the conservation of marine turtles held in Poreč, Croatia, October 2018 and integrated in the present book.

Apart from the project's technical and financial support for the North African countries and to ensure the success and sustainability of the project activities, SPA/RAC organized a regional training session (June 2018 in Dalyan, Turkey) where main stakeholders from Libya were represented.

The results of marine turtle research and conservation in Libya have not been very well promoted or shared at the regional level, as always claimed by the scientific community. However, this did not affect the commitment of the authority, research institutes, and even civil society towards Marine turtle conservation to safeguard Mediterranean Biodiversity.

Indeed, close collaboration at national and regional levels made possible the edition of the present book, which will fill some gaps to further complete the marine turtle picture in the Mediterranean.

Furthermore, The National Action Plan for the Conservation

of Marine Turtles and Their Habitats in Libya has been updated, reviewed and adopted by the main stakeholders in Libya (sea users, professionals, fishermen, public institutes, individual researchers, NGOs active in marine conservation) during an online national workshop held on the 9th of December 2020 within the framework of the implementation of phase 1 of the Mava Marine turtles project (2017-2020).

Through the second phase of the project (2020 - 2022), SPA/RAC will continue supporting Libya to implement its national action plan for the conservation of marine turtles and its habitats, besides the nesting monitoring, the national stranding network will be set up and promoted at a national level. The LibSTP team will focus on working with key actors, mainly the local communities, in Sirte and Farwa to achieve effective and sustainable protection of these priority areas.

Chapter 1

Nesting Ecology of Sea Turtles in Libya

By Abdulmaula Hamza, Almokhtar Saied, Salih Diryaq, Atef Ouerghi, Imsaed Bofliga, Abd -Elhafid El-Ganaieen, Amer Aljamel, Imed Jribi

1. INTRODUCTION

Two species of turtle are nesting in the Mediterranean, the Loggerhead turtle (*Caretta caretta*) and the Green turtle (*Chelonia mydas*). The Leatherback turtle (*Dermochelys coriacea*) is also recorded regularly in this sea, while the other two species (*Eretmochelys imbricata, Lepidochelys kempii*) are rare in the Mediterranean (Casale and Margaritoulis, 2010, Casale *et al*., 2018). Loggerhead turtle main nesting sites are located in Greece, Turkey and Libya, with increasing evidence of minor nesting in Southern Italy, Malta, Algeria, Tunisia, Lebanon, Syria and Egypt (Jribi et al., 2006; Ben Hassine et al., 2011; Jribi, 2017, Benabdi & Belmahi, 2020). The green turtles are exclusively nesting in the eastern basin of the Mediterranean, i.e. Cyprus, Syria, Lebanon, and Turkey (Hoschied et al 2019). No nesting activity of either species has been documented for Morocco, Monaco or the eastern Adriatic (Casale *et al*., 2018).

The Parties to the Barcelona Convention adopted in 1989 the Action Plan for the Conservation of Mediterranean Marine Turtles, which was later revised in 1999 and 2006 (UNEP MAP RAC/SPA, 2007). The contracting parties, including Libya, confirmed their commitment to the conservation of marine turtles by including the five species of sea turtle recorded for the Mediterranean in the List of Endangered and Threatened Species annexed to the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean. Marine turtles also protected under several other regional and international conventions and organisations. Table 1.1 details the current conservation status of each marine turtle species.

Table 1.1. IUCN Conservation status of sea turtle species and relevant international agreements, directives and conventions concerning sea turtles of the Mediterranean sea with listed annexes, applicable recommendations and regulations (adapted from Caminas et al., 2020)

		IUCN RED LIST CATEGORY AND CRITERIA (year of publication)		RELEVANT INTERNATIONAL AGREEMENTS FOR THE PROTECTION OF WILDLIFE IN THE MEDITERRANEAN					
COMMON NAME	SCIENTIFIC NAME	GLOBAL	MEDITERRANEAN	EU Habitats Directive Annexes	SPA/BD Protocol (Barcelona Conven- tion) Annexes	CITES Appendices	CMS Appendices	GFCM Recommendation	ICCAT Recommen- dation
Loggerhead turtle	*Caretta caretta*	VULNERABLE (2017)	LEAST CONCERN (2015)	II, IV					
Green turtle	*Chelonia mydas*	ENDANGERED (2004)	Not Evaluated	II, IV	II				
Leatherback turtle	*Dermochelys coriacea*	VULNERABLE (2013)	Not Aplicable	IV					
Olive ridley	*Lepidochelys olivacea*	VULNERABLE (2008)	Not Aplicable	–	–	I	I, II	GFCM/35/2011/4 on the incidental bycatch of sea turtles in fisheries in the GFCM Competence Area	Rec: 13-11 on the by-catch of sea turtles in ICCAT fisheries
Kemp's ridley	*Lepidochelys kempii*	CRITICALLY ENDANGERED (2019)	Not Aplicable	IV	II				
Hawksbill turtles	*Eretmochelys imbricata*	CRITICALLY ENDANGERED (2008)	Not Aplicable	IV	II				
African softshell turtle	*Trionyx triunguis*	VULNERABLE (2016)	CRITICALLY ENDANGERED (1996)	–	II	II	–		

1.1. Nesting of turtles in Libya

Information on sea turtle nesting activity in Libya dates back to the late 1970s; several researchers have reported tracks of Loggerhead sea turtles on the beaches of Kouf National park (Herbert, 1979; Armsby; 1980; Schleich, 1987). After the adoption of the first version of the Regional Action Plan for the conservation of Marine Turtles in the Mediterranean in 1999, the whole Libyan coast has been surveyed using a single prospecting method to identify important nesting beaches and nesting density, the first survey in 1995 covered 50 beaches (142 Km) from the Egyptian border to Sirte revealed nests (Laurent et al, 1995), the second survey in 1996 targeted the area (209 Km) between Sirte and Misurata (Hadoud & El Gomati, 1996); then in 1998, a survey completed the remaining distance (407 Km) between Misurata and the Tunisian border (Laurent et al, 1999). The main findings of these surveys were: Loggerheads are the only nesting species in Libya; the pristine status of Libyan coasts and lower human activities allowed Libya to host one of the largest nesting sea turtle populations in the Mediterranean. However the findings of the above-mentioned surveys (regardless of its significant importance), were based on single prospections, with no continuous monitoring of the nesting beaches throughout the nesting season, therefore it cannot reflect the actual size of the nesting turtle population.

1.2. The Libyan Seaturtle Program

Following the recommendations and priorities set by the earlier surveys, the actions listed at the MAP regional Action for the conservation of sea turtles in the Mediterranean (UNEP-MAP-RAC/SPA, 2001), the National Action Plan for the conservation of sea turtles and their habitats in Libya (UNEP-MAP-RAC/SPA, 2003, revised in 2019), The Nature conservation department at the Environment General Authority (EGA), in collaboration with the Marine Biology Research Centre (MBRC) and volunteers from the General Movement for Libyan Scouts (GMLS) and a financial and technical support from the Specially Protected Areas Regional Activity Centre (UNEP-MAP-SPA/RAC), has established in 2005, a national program for the monitoring of nesting activity and conservation of loggerhead sea turtles, under the name of Libyan Sea turtle Program LibSTP. The start of monitoring work was initiated at three nesting beaches located to the west of Sirte, based on previous surveys as these three beaches showed relatively higher nesting density.

1.3. Objectives of the Libyan Seaturtle Program

1. Long-term monitoring of the most important nesting sites for sea turtles in Libya.
2. Capacity building for Libyan conservationists and raising public awareness.
3. Identification of threats that have impacts on both the turtle population and their nesting sites in Libya
4. Established collaboration with other conservation initiatives for sea turtles in the region.

To perform monitoring work for the selected nesting sites, the program required trained Local conservationists from EGA and other institutions. The technical assistance by RAC/SPA enabled seven Libyans to acquire practical training on Turtle monitoring techniques at Lara reserve in Cyprus. This training has contributed to establishing a national training programme to prepare monitoring teams that performed the work at the known nesting sites in Farwa, Sirte, Misurata, Benghazi, Al-Jabal Al-Akhdar, and Tobruk nesting sites.

This chapter presents a synthesis of the current knowledge regarding nesting ecology and conservation status of sea turtles in Libya, from 2005 to 2019.

2. GENERAL OVERVIEW OF NESTING SITE OF MARINE TURTLE IN LIBYA

Although the Libyan coast is quite homogeneous and lacks natural barriers (Fig.1.1). The coastline was divided into five distinct zones (zones 1-5); each consists of several sea turtle nesting beaches with variable importance. In this study the most monitored areas fall under zone 1 (A, Misratah), zone 2 (B, Sirte), and zones 4 & 5 (pooled under C, Cyrenaica), details of nesting beaches at each of the three areas (A,B and C) are shown in Fig.1.2. The following is a brief description of each coastal zone, based on geomorphological aspects of the coastline, followed by the results obtained through the fieldwork, carried out between 2005-2019.

2.1. Ras Ajdir (Tunisian border) to Misurata - Zone1

This is one of the heaviest populated zones on the Libyan coast, where Tripoli and other nearby smaller cities make the major population concentration areas. The coastline is characterized by sandy beaches from Ras Ajdir to Zawia, with several salt marshes (Sabkhas) bordering the sand dunes. East of Zawia, the coast morphology is dominated by medium height sandstone formations with smaller stretches of sandy beaches of limited importance to Sea turtle nesting, such as Wadi Ramel and Wadi Turghat to the east of Tripoli. several small sea heads, and some narrow bays at wadi mouths, such as in Wadi Kaam and Wadi Lebda (Leptis). The coastal elevation in this zone is by the contact of Jebel Nafusa foothills with the Sea (from Garabulli eastwareds to Khoms). Due to high human population activity nesting was low in general, however in recent years a growing number of nests were recorded at Farwa island beaches and on other beaches of Tajoura and Garabulli.

2.2. Misurata to West Sirte - Zone 2

A continuous sandy coastline section, with simple coastal structures, with few medium-elevated sand dunes formed with trapping sand under halophytic vegetation. The coastline topography east of Misurata shows a drastic change in terms of the abundance of sandy beaches intersected with several wetlands (sabkhas), and significantly lower human population activity. This area has several important nesting beaches of national importance (Table 000). This zone is separated from the coastal highway by vast salt marshes, making it hard to assess all beaches continuously, which represent a priority and a challenge for monitoring efforts.

The most extensive Sabkhas are found in this sector, such as Sabkhat Qaser Ahmed, Taourgha, Al-Hisha, all of these wetlands are separated from the sea by narrow sandy beaches, with some openings that allow seawater to enter to the Sabkha during winter.

2.3. Sirte to Ajdabiya (Zone 3)

This zone includes the central and eastern sections of the Gulf of Sirte (Sidra), with Sirte and Ajdabiya are the main human settlements, in addition to several oil terminals (Sidra, Ras Lanuf and Brega). The beach is generally sandy, with the desert dunes in direct contact with the Mediterranean sea. The most southern point of the Mediterranean is found here at Bisher village. It is among the most important Sea Turtle nesting zones along the Libyan coast. Available data are obtained from the west of the Sirte sector, as it was the base of training, research, and monitoring work since 2005 by the Libyan Seaturtle Program. Based on 2006-2007 published data, the first, fourth, fifth, and seventh highest nesting density beaches are located in this zone. However, more work needs to be conducted in the area from East Sirte to Ajdabiya, which include some areas that were never been monitored in the past, and it may involve increasing the potential number of nests laid on the Libyan coastline significantly. The presence of Oil terminals in this zone, may pose a threat to the nesting and foraging habitats of Seaturtles in the case of oil spills.

2.4. Ajdabiya to Tolmithah (Zone 4)

This sector is featured by the presence of coastal slopes and caves in the eastern section, which are made either by karstic or marine erosion in limestone medium elevated cliff coast. The remaining part is less elevated and specifically rich in coastal lagoons and sabkhas, that are connected to the sea, and/or having freshwater input, making a brackish rich habitat.

This area is also very important, being less populated and forms the eastern end of the Gulf of Sirte, and extends to cover the Benghazi area to the western edges of Aljabal Alakhdar region. Several important nesting beaches were identified in this zone, including the second most important site of Al-Mtefla. Other potential high nesting beaches can be identified with more monitoring work here, especially at Shat El-Badin and El-Magroon beaches southwest of Benghazi and Deryanah beaches to the north of the city.

2.5. Wadi Kouf to Imsaed (Zone 5)

The steepest and most elevated Libyan coasts are found in this section, as some limestone coastal formations reach over 100m (Ras Hilal and Lathroon), as Al-Jabal Al-Akhdar (Green mountain) become in contact with the sea, directly or with a very narrow coastal plain. This area also is relatively having more coastal heads (e.g. Ras Buazza, Ras Karsa, Ras Hilal, and Ras Amer) than others. The high elevated slopes are intersected with deep narrow wadis, emptied in narrow bays such as Wadi Khaleej and Wad Jarjarumma.

The eastern section of this sector appears as an arch in a north-south direction, forming the Gulf of Bumbah, with intense sandy formations, and low topography with the extensive presence of coastal lagoons and Sabkhas. A group of small islands exists in proximity to the shores of this section, such as the island of Ulbah (Syn. names Elba or Umm Al Marakeb island) to the east, and Barda'a island to the northeast, and islands of Wetya (Fteha/ Fat'ha), Misurata and Um Elgarami at the middle of the gulf. Several wadis feed this Gulf as well, such as Wadi Tememi, Wadi Qusaibat, and Wadi El-Maalaq.

To the east of Bumbah bay, the coastline changes into the east-west direction, with the highest proportion of curving coastline in the country when it reaches Tobruk, with short wadis and steep edges directed to the Sea (E.g. Wadi Ung Elanz) in small to medium-sized bays. The Miocene limestone formations cover most of this sector, from coastal slopes of more than 40 m east to Tobruk. The remaining parts of the coast vary from low-medium elevated rocky or gravel coasts, with limited small sandy beaches (in some areas less than 1000 m, as in Ain Ghazala northern beaches).

This zone includes several important nesting beaches, including Kouf National Park sandy beaches (about 20 km), beaches of Ain Al- Ghazala and other beaches to the west of Tobruk. Several beaches need more monitoring as data on this area dates back to the first surveys conducted in 1995 (Laurent et al., 1996). They face the increasing threat of sand mining which caused severe beach erosion at several sites, especially at Gardabah (East of Ain Ghazala) and the Kouf National Park beaches, due to lack of law enforcement and management.

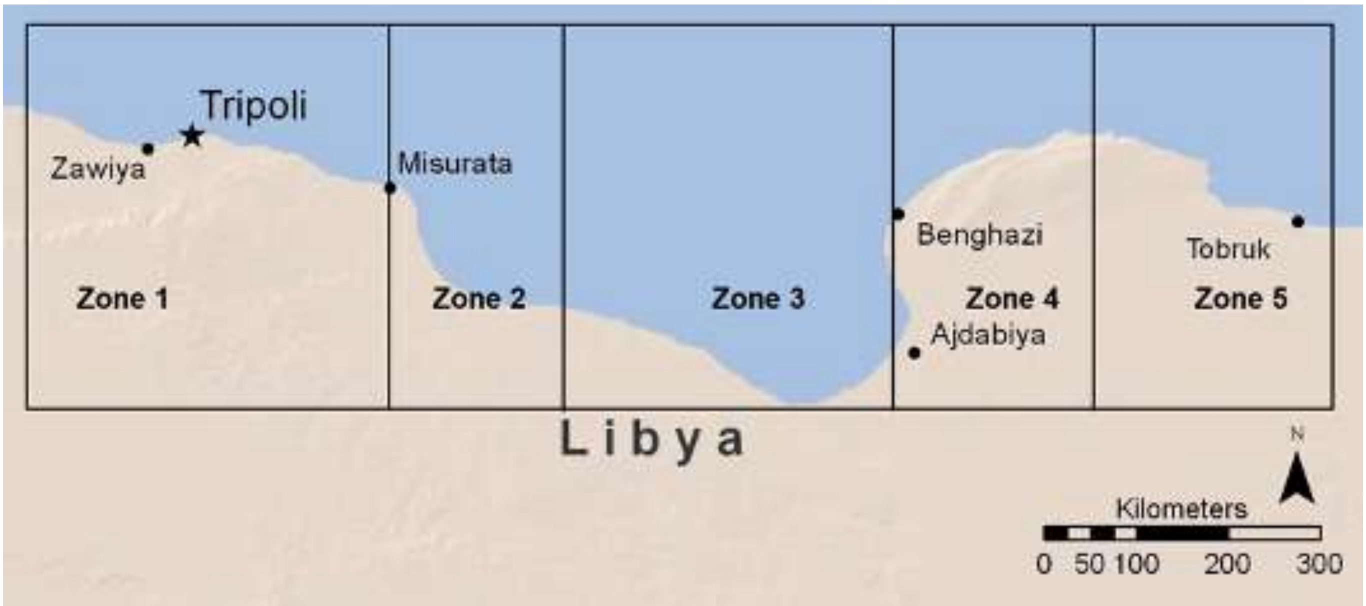


Figure 1.1. Map of geomorphic zones of the Libyan coastline

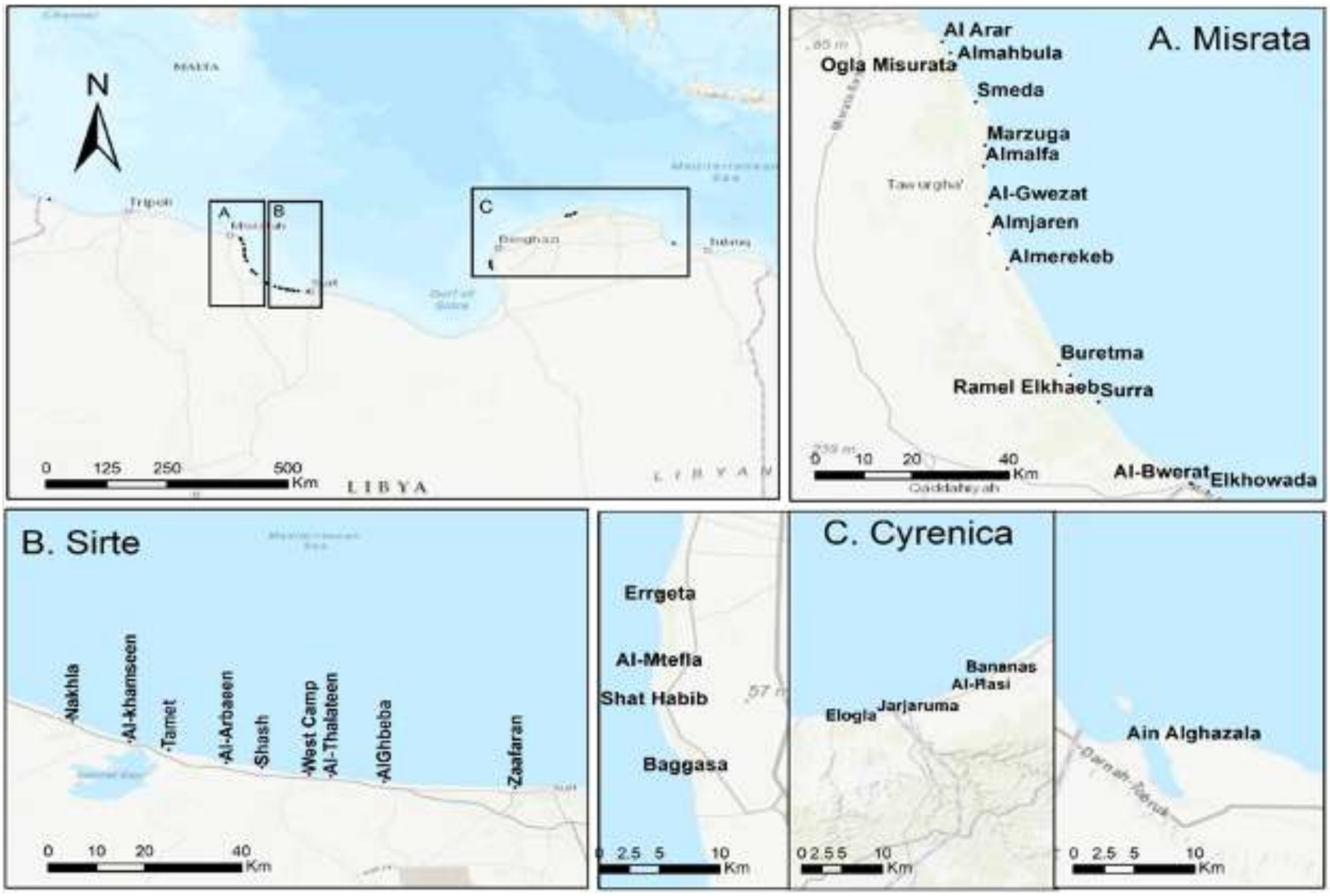


Figure 1.2 Monitored nesting beaches along the Libyan coastline

3. MONITORING METHODOLOGY

The monitoring methods used in nesting beaches, follow the methods of Demetropoulis and Hajichristophorou (1996) The following methods were used to report nesting data and follow up on the fate of laid nests. Based on earlier surveys, the start of nesting season at each nesting area was determined by starting beach surveys to record nesting activity at the third week of May, with peak nesting activity expected in June and July. Beach surveys were conducted either by foot or using vehicles at longer stretches of the coast.

Based on the shape of the track, left by front and hind turtle flippers, nesting signs were classified according to the method used in Laurent et al. (1999), as the following crawl tracks (Figure 1.3):

- U-shape Crawl Track (UCT): crawl track without any digging attempt.
- False Crawl Track (FCT): crawl track with one or more digging attempts, without egg deposition.
- Nesting Crawl Track (NCT): crawl track leading to a nest.
- Crawl Track (CT): old crawl track that no means of classification is available.
- Nest (N): Nest without crawl track, either opened by a predator or a poacher or remained in natural condition.

At each nesting beach, all types of crawl tracks and nest signs were recorded at a prepared data form. Collected data include Date, time, beach name, track type, coordinates (using hand GPS), nest depths (total depth and depth from surface until upper egg group), nest number, nest condition (natural, poached, or predated), protection method (*in situ* protection or translocation to hatchery). After hatching within three days after hatching, the nest opened to collect data on Clutch size, the number of hatchlings (using eggshells total number), totally dead in egg embryos, and dead in nest hatchlings, Early and late embryonic stages. Hatchlings and embryo tissue samples were collected for the genetic study from some of the monitored beaches. Stranded turtles during nesting season were also documented in a separate form.

Figure 1.3. Examples of Sea Turtle Crawl Tracks

4. NESTING ACTIVITY OF SEA TURTLES IN LIBYA (2005-2019)

Nesting activity is spread along the coast of Libya, monitoring efforts in the period of 2005 - 2019 showed that the nesting density was variable among the three monitored zones. This variability can be caused because of inter-seasonal nesting activity (number of turtle emergence) and other factors can also be responsible in this variation, among them the amount of monitoring effort (number of monitoring trips/season), number of monitored beaches at each season, the means of monitoring (walking vs car), and the amount of human activities on the beach, which can erase nesting tracks.

The highest mean track density was at Sirte beaches, with 14.5 ±8.5 tracks/Km (range 1.8-24.4 tracks/km). While the lowest density was reported from Misurata nesting beaches with 2 ±2.1 tracks/km (range 0.1-5.9 tracks/km). Relatively lower monitoring effort and higher human activity (driving vehicles on sandy beaches of this area), prevented recording of an important proportion of nesting activity and nests. This low track nesting activity trend (and consequently number of nests) in Misurata beaches can be seen in decreasing trend from 5.9 track/km in 2007 to less than 0.1 tracks/km in 2018. Track density in Cyrenaica was in middle area between Sirte and Misurata nesting beaches (Figure 1.4), but other problems occur there, mainly natural predation of nests, and more importantly the common practice of illegal sand mining and intrusion of seawater to the cleared beaches, is changing dramatically the geomorphology of nesting beaches of Cyrenaica (Table 1.2) .

Nest density followed similar trend like in tracks density (Figure 1.5), Sirte had the highest mean nest density with 10.1 ±5.1 nest/Km (range 4.1-17.2 nest/Km), while the lowest mean nest density was also in Misurata with 1.3 ±1.0 nest/Km (range 0.4-2.9 nest/Km). To standardize results, due to differences in number of monitored beaches, the tracks and nest density were calculated for each year at each zone based on the total length of monitored beach at that particular season (Table 1.2).

Monitoring was not conducted in 2005 at Misurata and Cyrenaica as the LibSTP was just founded at Sirte. In 2008 no monitoring was conducted in Sirte and Misurata due to administrative and financial constraints. Similar situation was in 2019 at Misurata. In 2011 - 2016 no monitoring due to the security situation in Libya, after the 2011 change. Data for the 2020 season was not included as the results are not available yet at the time of writing this book.

The total number of nests across the monitored seasons (Table 1.2) varied from 10 at Al-Jabal Al-Akhdar to 393 at the Gulf of Sirte nesting beaches. Taking into account the lengths of monitored beaches, the highest nesting density was recorded at Sirte nesting zone.

Regardless of the already identified nesting zones, the overall length of monitored nesting beaches in Libya is 192.56 km (Figure 1.5). This represents 17.7 % of the total sandy beach length (1089 km) in the country. Therefore, several other nesting beaches need to be discovered and monitored regularly, especially in the area between Sirte and Ajdabiya, Ajdabiya to Benghazi, north of Benghazi to Aljabal Alakhdar and the area to the east of west and Tobruk. Nesting beaches can be ranked up on their respective nesting density (nests/km, Table 1.3), or based on average number of laid clutches per season (Table 1.4). In both cases the beaches of Sirte were the top four sites, this is due to the relatively high nesting activity, but also due to intensive monitoring effort between 2005 and 2019.

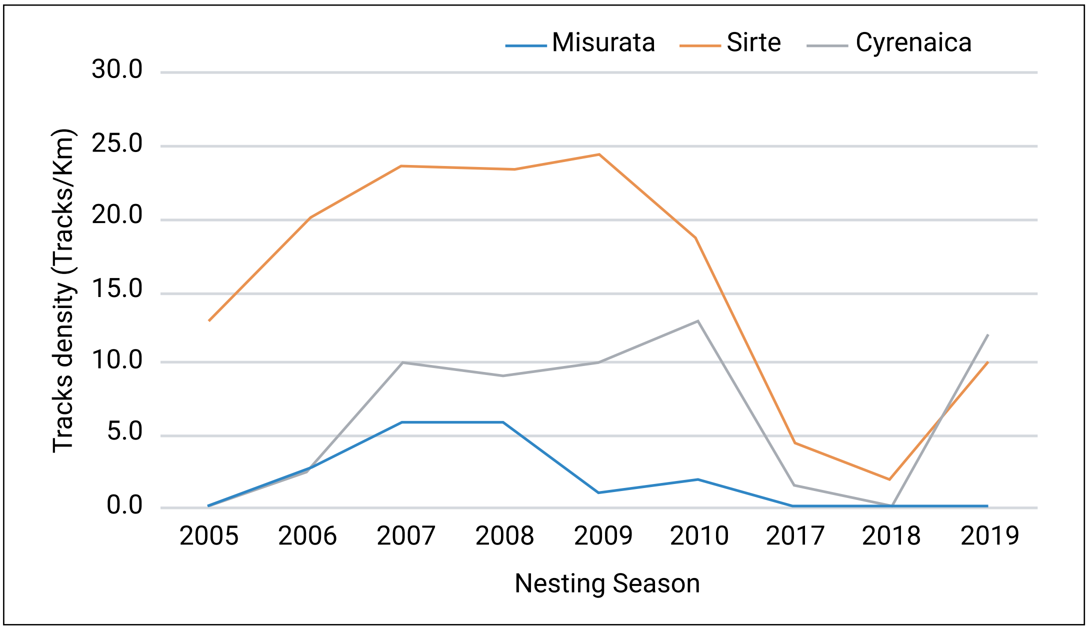


Figure 1.4. Tracks density at annually monitored loggerhead turtle nesting beaches from Misurata, Sirte and Cyrenaica, Libya

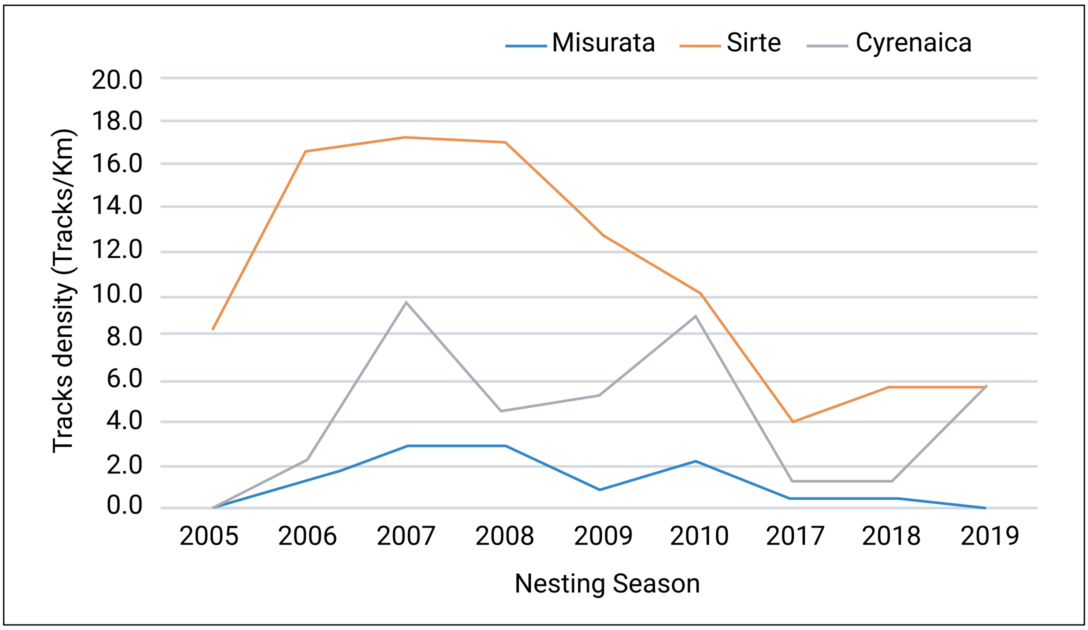


Figure 1.5. Nesting density at annually monitored loggerhead turtle nesting beaches from Misurata, Sirte and Cyrenaica, Libya

Table 1.2. Mean Nest (nest/km) and track (track/km) densities of loggerhead sea turtles in Libya (2005-2019)

Zone	Nest or track	2005	2006	2007	2008	2009	2010	2017	2018	2019	Max	Min	Mean	± SD
Misurata	Nests/km	NS	1.3	2.9	NS	0.9	2.1	0.4	0.5	NS	2.9	0.4	1.3	1.0
	Tracks/km	NS	2.6	5.9	NS	0.9	2.1	0.3	0.1	NS	5.9	0.1	2.0	2.1
Sirte	Nests/km	8.2	16.8	17.2	NS	12.9	10.2	4.1	5.6	5.8	17.2	4.1	10.1	5.1
	Tracks/km	13.0	19.9	23.4	NS	24.4	18.7	4.5	1.8	10.1	24.4	1.8	14.5	8.5
Cyrenaica	Nests/km	NS	2.4	9.6	4.5	5.2	9.0	1.2	0.0	5.8	9.6	1.2	5.4	4.0
	Tracks/km	NS	2.4	10.0	9.2	10.2	12.9	1.4	0.0	11.9	12.9	1.4	8.3	5.3

NS= no surveys conducted.

Table 1.3. Ranking of monitored turtle nesting beaches in Libya based on Average number of nests per kilometres (nest/km)

	Beach-Length	beach name	2005	2006	2007	2008	2009	2010	2017	2018	2019	Average nest/season	seasons
1	8.54	Al-Arbaeen (Tamet)		154	84		65	103	29	61	67	80.4	7
2	4.85	Shash					105	94	49	66	70	76.8	5
3	5.12	Al-Gbeba	30	139	154		81	35	28	43	22	66.5	8
4	12.94	Al-Khamseen							42	64	78	61.3	3
5	5	Zouitina						61				61.0	1
6	5.43	Al-Thalateen	47	66	80		49	65	50	72	43	59.0	8
7	5	Mtefla		16	104		22	28				42.5	4
8	3.82	West Camp	41	25	10		58	45	31	37	41	36.0	6
9	5	Boutraba					4	66				35.0	2
10	2.7	Ain Ghazala			36	33	59	22				37.5	4
11	9.42	Smeda		14	54		27	50		4		29.8	5
12	6.07	Arar		7	37		4	34				20.5	4
13	5	Al-bouwerat							20	7	31	19.3	3
14	17.7	Almjaren		29	22		17	20	6	2		16.0	6
15	5.49	Al-Ghwezat		13	33		11	7				16.0	4
16	12.9	Zaafaran							9	13	20	14.0	3
17	5.1	Al-Nakhla							17	1	21	13.0	3
18	3.8	Ugla		4	30	7		27	3		5	12.7	6
19	10.9	Khawada		10	2			34	3			12.3	4
20	2	Bananes		10	18	8	16	17			3	12.0	6
21	5.32	El-Mahbula		10	22		1	15				12.0	4
22	3.3	Jarjaruma		5	22	5	4	20	5		16	11.0	7
23	1.5	Al-Malfa		3	37		9	5		1		11.0	5
24	7.09	Asswawa							6	15		10.5	2
25	1.3	Al-Hasi		4	8	5	3	11	2		36	9.9	7
26	1.4	Abulfraes			9							9.0	1
27	5.46	Marzouga		8	17			2				9.0	3
28	8.11	Al-Ramel Al-Khaieb		6	11		4	6		1		5.6	5

29	0.95	Ugla Misratah		4	2		4	4		12		5.2	5
30	5.87	Buretma		5	4		4	3		1		3.4	5
31	4.8	Elmerekeb		2	6		1	2	3	1		2.5	6
32	4.84	Surra		1	2			1				1.3	3
	186.72	Total	118	535	804	58	548	777	303	401	453		

Table 1.4. Loggerhead turtle (*Caretta caretta*) nesting locations in Libya, with nests/yr > 10 and nests/km yr > 3.

	Beach-Length	beach name	2005	2006	2007	2008	2009	2010	2017	2018	2019	Nest Density (nest/km)
1	5.12	Al-Gbeba	30	139	154		81	35	28	43	22	103.9
2	5.43	Al-Thalateen	47	66	80		49	65	50	72	43	86.9
3	4.85	Shash					105	94	49	66	70	79.2
4	3.82	West Camp	41	25	10		58	45	31	37	41	75.4
5	8.54	Al-Arbaeen (Tamet)		154	84		65	103	29	61	67	65.9
6	2.7	Ain Ghazala			36	33	59	22				55.6
7	1.3	Al-Hasi		4	8	5	3	11	2		36	53.1
8	1.5	Al-Malfa		3	37		9	5		1		36.7
9	2	Bananes		10	18	8	16	17			3	36.0
10	5	Mtefla		16	104		22	28				34.0
11	0.95	Ugla Misratah		4	2		4	4		12		27.4
12	3.3	Jarjaruma		5	22	5	4	20	5		16	23.3
13	3.8	Ugla		4	30	7		27	3		5	20.0
14	9.42	Smeda		14	54		27	50		4		15.8
15	12.94	Al-Khamseen							42	64	78	14.2
16	5	Boutraba					4	66				14.0
17	6.07	Arar		7	37		4	34				13.5
18	5	Zouitina						61				12.2
19	5.49	Al-Ghwezat		13	33		11	7				11.7
20	5	Al-bouwerat							20	7	31	11.6
21	5.32	El-Mahbula		10	22		1	15				9.0
22	5.1	Al-Nakhla							17	1	21	7.6
23	1.4	Abulfraes			9							6.4
24	17.7	Almjaren		29	22		17	20	6	2		5.4
25	5.46	Marzouga		8	17			2				4.9
26	10.9	Khawada		10	2			34	3			4.5
27	8.11	Al-Ramel Al-Khaieb		6	11		4	6		1		3.5
28	12.9	Zaafaran							9	13	20	3.3
	186.72		118	527	792	58	543	771	294	384	453	

5. REPRODUCTIVE PARAMETERS

The nesting season of loggerhead sea turtles in Libya follows the general trends of the species nesting dates; with nesting, the peak occurs in June-July. The nesting activity starts usually by mid-May and extends until early September.

5.1. Curved Carapace Length of nesting females

The Mediterranean nesting loggerhead turtles are known to be significantly smaller in size compared to other nesting loggerheads in the World (Broderick and Godley, 1996). Curved Carapace Length (CCL) and Curved Carapace width (CCW) were measured for nesting females when found on beach during egg-laying process, or by measuring stranded and injured turtles when encountered (Figure 1.6). The mean Curved Carapace Length (CCL) of nesting loggerhead females in Libya was 77.9 ±8.5 (range 67-110 cm),. This length is even slightly smaller than the average (CCL 79.1 cm) of the Mediterranean nesting loggerheads (Casale et al., 2018), while the mean Curved Carapace Width (CCW) was 68.7 ±6.1 (range 58-93 cm). Detailed carapace sizes per nesting zone and sample size are shown in Table (1.5).

Table 1.5. Curved Carapace Length (CCL) and width (CCW) of nesting loggerhead female turtles in Libya

Nesting Area	No. of seasons	Mean CCL	CCL Range	Mean CCW	CCW Range	Sample size
Misurata	3	78.8	58-110	69.6	54-88	5
Sirte	6	69.4	42-85	61.8	36-74	40
Cyrenaica	2	88.8	72-100	77.3	68-95	6

Figure 1.6. Photos of LibSTP staff measuring sea turtle CCL and CCW

5.2. Stranded Sea Turtles

A total of 151 stranded loggerhead turtles were found on monitored nesting sites along the Libyan coast, between 2005 and 2019 (Table 1.6 & Figure 1.7), with overall mean CCL of 67.8±14.3 Cm and mean CCW of 59.2±11.9 Cm. A 61 % (n=93) was reported from the most monitored zone of Sirte, followed by 25.2 (n=38) from Zuwara in eight months of Feb-September 2019, While 9.9 % (n=15) and 3.3 % (n=5) were reported from Cyrenaica and Misurata respectively. The mean CCL at Sirte zone was 67±13.8 Cm (range 33-114 Cm), Misurata zone was 78.8±19.1 Cm (range 58-110 Cm), in Zuwara was 66.5 ±10.3 Cm, and at Cyrenaica it was 76.7±20.6 Cm. Data for CCW fall within the range of other Mediterranean nesting populations (Margaritoulis et al, 2003).

Table 1.6. Curved Carapace Length (CCL) and width (CCW) of stranded turtles in Libya.

Zone	Seasons	#of turtles	Measure	min	max	Mean	SD	SE
Cyrenaica	2008 - 2009 & 2019	15	CCL	38	100	76.7	20.6	0.3
			CCW	34	95	65.0	17.7	0.3
Misurata	2008 - 2009 & 2017	5	CCL	58	110	78.8	19.1	0.7
			CCW	54	88	69.6	21.1	0.6
Sirte	2005 - 2010, 2017 & 2019	93	CCL	33	114	67.0	13.8	0.0
			CCW	24	74	66.3	11.5	0.0
Zuwara	2019	38	CCL	42	87	66.5	10.3	0.1
			CCW	33	76	57.9	9.0	0.1

Figure 1.7. Photos of stranded Loggerhead sea turtles

5.3. Clutch size

Clutch size is the total number of eggs in a nest, it is either determined at the time of egg-laying or during the inspection of nest contents after hatchlings emergence is completed. Table (1.7) shows collected data on clutch size in four nesting zones of Libya. The clutch size ranged from 11 to 160 eggs/nest, with an overall average of 79.32 eggs/nest. This average is similar to most Mediterranean nesting loggerhead clutch sizes but smaller than what was recorded in Greek nesting sites (Margaritoulis et al., 2003).

There is a positive correlation between clutch size and adult female body size reported for most turtle species. However in loggerhead conflicting reports exist about this aspect, for example, Hirth (1980) found no significant linear relationship between carapace length and clutch size, while in Kefalonia, Greece, Hays and Speakman (1992) found a significant positive relationship. This aspect still needs to be explored for the Libyan nesting populations.

Table 1.7. Mean clutch size of Loggerhead Turtle nesting in Libya

Nesting Area	No. of seasons	mean	Range	Sample size (nests)
Misurata	4	83.24	38-132	69
Sirte	5	83.21	11-160	932
Cyrenaica	4	74.93	30-117	31

5.4. Incubation duration

The incubation period is defined as the period in days between a newly laid nest and the first record of emergence by either direct observation of hatchlings or their crawl tracks emerging from nests (Jribi et al, 2013).

In the Mediterranean Incubation duration of Loggerhead sea turtles have particularly shorter nesting sites compared to the rest of the world (Margaritoulis et al 2003). The incubation duration in Libyan nesting beaches follows the general trend in other Mediterranean beaches, with a tendency to produce more females than males (see the chapter on sex ratio). The available data from Sirte and Misurata nesting zones indicates that incubation duration ranges from 45-72 days (Table 1.8). Further information is required to investigate any differences in incubation duration lengths that might exist between Libyan nesting beaches.

Table 1.8. Incubation period of Loggerhead Turtle clutches in Libya

Nesting Area	No. of seasons	Mean (day)	Range of individual nest	Sample size (nests)
Misurata	1	53,17	46-60	34
Sirte	4	50,5-58,02	45-72	160

5.5. Mass and morphometrics of hatchlings

Data collected on weight and morphometrics of sea turtles in Libya are restricted to one nesting zone of Sirte (Table 1.9). Mean hatchling carapace length was 3.92 cm, this is close to data collected in other Mediterranean beaches, such as in Tunisia 4.30 (Jribi et al 2002), 4.10 cm in Cyprus (Demetropoulis and Hadjichristophorou, 1996), 4.04 cm in Greece (Margaritoulis, 1982). The mean Carapace length for hatchlings in Libya was 3.04cm, while it recorded 3.21 Cm in Tunisia (Jribi et al 2002), and the mean weight was 13.91g compared to 14.26g in Tunisia and 16g in the whole Mediterranean (Demetropoulis and Hadjichristophorou, 1996).

Table 1.9. Mass and dimensions of hatchlings

Nesting Area	No. of seasons	Sample size	Mean SCL-hatchling	SCL Range	Mean SCW-hatchling	SCW Range	Mean weight (g)	Weight range (g)
Sirte	1	498	3,92	3,1-4,5	3,04	2-3,1	13,91	7,9-17,5

5.6. Adult Turtle tagging

A total of 38 adult female loggerhead turtles were tagged on the trailing edge of either one or both front flippers, to provide a means of unique identification of these nesting females using inconel made specifically for the Libyan Seaturtle Program. The tag code starts with two letters (LY) for Libya, followed by a three digit number (001). A contact email of Libstp@gmail.com is provided on the tag for reporting these turtles once they are encountered in Libya or abroad (Figure 1.8).

The majority of these tagged turtles are from Sirte (n=33), followed by 4 in Misurata and a single turtle at Ain Al-Ghazala in Cyrenaica. Most tagging was conducted in 2009 and 2010, coinciding with Satellite tagging work, which is detailed in Chapter 3 of this book. On May 27th 2009 a female leatherback turtle of CCL 122 Cm, was found by a local fisherman, entangled in fishing nets near Al-Kowada beach in Misurata zone, where it was rescued and given tag numbers LY0016-LY0017 on both front flippers.

Figure 1.8. Tagging of female nesting Loggerhead sea turtle.

5.7. Nest predation

levels of nest predation in Libya by foxes, feral dogs, and Jackals are high (44.8 % during 1995 survey; and 45.4 % during 1998 survey; see Laurent et al., 1996 and 1999). The following (Table 1.10) shows the results of the annual impact of predation on nesting zones of Libya.

The results show that the highest predation levels are found at Cyrenaica zone, as 71.42 % of the nests at Ain Al-Ghazala beaches were depredated by foxes (Figure 1.9) and Jackals, followed by beaches of Al-Jabal Al-Akhdar and Benghazi (33.66 and 22.33 % respectively). Predation levels in Sirte and Misurata beaches were significantly lower. Foxes, feral Dogs, and Jackals tend to be more frequent at the beachside during the egg-laying period. Jackals are found exclusively at both Ain Al-Ghazala and Al-Jabal Al-Akhdar nesting zones, and there are field observations in 2007 of a Jackal attack on a nesting female turtle at Al-Jabal Al-Akhdar nesting zone.

The other predator of an un-quantified impact yet is the Ghost Crab Ocypode cursor to a lesser extent represents another active nocturnal predator, on both eggs and hatchlings; holes used by this species have been observed at different densities in most nesting beaches of Libya.

In the Mediterranean, predation is responsible for losing 36 % of nests in Cyprus (Broderick and Godley, 1996) to 70-80 % of nests in the Dalyan beaches of Turkey (Erkakan, 1993). Further studies are needed to quantify the density distribution and predation effect of the different predator species on both nests and nesting females in Libya.

Table 1.10. Mean and range of predated loggerhead turtle nests in Libya

Nesting Area	No. of seasons	mean	Range	Sample size (nests)
Misurata	4	12,35	(10,07-15,26)	656
Gulf of Sirte	4	16,24	(0,50-29,1)	838
Benghazi	3	22,33	(8,45-58,62)	197
Al-Jabal Al-Akhdar	4	33,66	(17,39-44,00)	210
Tobruk	3	71,42	(69,70-85,71)	105

Figure 1.9 Predated sea turtle nests by Red fox *Vulpes vulpes*

5.8. Poaching of turtle nests

Poaching of sea turtle nests is illegal in Libya, however, due to low enforcement of regulations in this regard; it became a common problem at some nesting beaches. Data shows some notable increase of egg poaching even within the monitored zones (Figure 1. 10).

Believes of the medical benefits of turtle products is the main driver for the trade-in this species, however the EGA office in both Misurata and Sirte (where poaching levels are the highest, 13.08 and 13.11 % respectively) had conducted several efforts with local authorities to enforce regulations prohibit turtle product trading at local fish markets. No update on the trend of poaching after 2010, however, we anticipate that after the events of 2011 and the weakened enforcement of regulation by the state, such practices might have increased and their impact might also cause more loss of turtles produced from the Libyan coast.

Figure 1.10. Photos of poached sea turtle nest

6. TRAINING ACTIVITIES

The importance of Libyan beaches for sea turtle nesting, made it necessary to conduct capacity building program to train trainers. In this regard, the SPA/RAC support was crucial in providing training sessions at Lara nature reserve in Cyprus, in collaboration with Cyprus Wildlife Society (CWS), as several Libyan youths and researchers from EGA-LibSTP and other institutions in the country, obtained hand-on training for nesting beach monitoring techniques and nest finding, egg census and protection methods. This in addition of having practical experience of tagging adult Seaturtles. These sessions started in 2001 and continued with the grow of the LibSTP, as more staff are needed for several work stations along the coastline of Libya. Since its establishment in 2005, LibSTP considered training of staff as a priority, therefore a training base was setup in Sirte beaches, and over 40 Libyans acquired local training on Seaturtle monitoring methods, by those who obtained their training earlier at Lara reserve in Cyprus.

Training is not only required for beach monitoring, other aspects of Seaturtle work required additional training, for example in conducting injured turtle veterinary care and treatment and training on genetic studies. Both were kindly provided with technical assistance from SPA/RAC and the Zoological station Anton Dhorn in Naples, Italy. Other collaboration with this research station included satellite tracking of several adult loggerhead turtles in Libya, and this also included an important skills transfer to Libyans in equipping the turtle with satellite tracking instrument, and on how to release that tracked turtle.

7. THE NATIONAL WORKSHOPS ON SEATURTLES IN LIBYA

The LibSTP in collaboration with EGA, SPA/RAC have organised two national workshops. The first was organised in Sirte during August 2006, with invited guests from other Mediterranean countries and of WWF Mediterranean office. During the workshop various presentations were made about the Mediterranean Action plan for the conservation of marine turtles, the WWF Action Plan and the Tunisian experience in Turtle conservation. The second part was dedicated to the work of the different LibSTP field teams. The workshop emphasize the importance of LibSTP for both Libya and the Mediterranean region. Workshop concluded with a discussion about the future work of LibSTP, which should be regularly carried out and developed to study all the necessary eco-biological parameters (which is presented eventually in this book). A side event was organized back to back to the workshop showing the fieldwork procedure of LibSTP team in Sirte, the achievements and photo gallery of the 2005 and 2006 seasons.

The second national workshop was organised on 14 April 2010 at EGA headquarters in Tripoli, to present findings of the program, and discuss the needs of each field team in terms of technical or financial support. The workshop was co-organised with SPA/RAC, and attendees included represenatives from Libyan universities, NGO's and the representative of UNDP in Libya. Dr. Imed Jribi from University of Sfax in Tunisia, also attended this workshop and presented findings of Sex ratio study in Sirte beaches (more details in the following chapter). Furthermore, Mr. Atef Ouerghi who was the program officer in charge of marine turtle conservation at SPA/RAC, presented the initial results of tracking and genetic studies conducted with assistance from the Zoological station in Naples.


مرحبا بضيوفنا الكرام
WELCOME YOU ALL IN SIRTE

8. PUBLIC AWARENESS ACTIVITIES

Public awareness is also an important activity under the objectives of LibSTP. The following is a selection of awareness activities conducted along the past years:

1. Since its establishment, the LibSTP had a weekly reportage and interview during the national TV broadcasting from Sirte, to present information on the program and its activities.
2. The former coordinator of the program, Dr Hamza, was live on Aljazeera TV, to discuss the importance of Libyan coastline to the Mediterranean rockery of Seaturtles.
3. In 2005 at the start of the program, we had a very good collaboration with Libyan Scouts Movement in Sirte, who helped in beach monitoring and conducting awareness activities in the city.
4. In 2007 at Misratah, a technical meeting on regional conservation priorities in the Mediterranean was organised by the LibSTP and SPA/RAC, with presence of experts from several countries. The Misratah declaration at the end of this meeting was the focus of national TV, Radio and newspapers, which indirectly help in raising awareness.
5. Also during 2007, Aljazeera produced a reportage on the work of the LibSTP in Sirte (Link)
6. In 2010, during the release of several loggerhead turtles from Misratah, for tracking study, the event was attended by school children, scouts, local fishers and the national media (Link).
7. The study of sex ratio field sampling in 2010 was also featured in a short video (Link)
8. Several short videos on the LibSTP works were produced since 2005. A short video was produced in 2005 season (Link) and 2006 season (Link), other videos also include these 1, 2, 3, 4, 5, 6.
9. In 2015, during the 23rd International Seaturtle Symposium, which held in Turkey, the work of three primary schools in Sirte was presented. Over 120 paintings and art works were on display at the main hall of the conference venue. Some of these were later donated to the silent auction of the symposium, and some three paintings were sold in auction. The obtained amount was used later to present gifts to the local school children at these schools.
10. Several Libyan TV channels recently continued to present the work of LibSTP on its broadcastings. Some examples are: example 1, example 2, example 3.
11. Several other NGOs in Libya, is increasingly producing media materials on bycatch (example 1, example 2, example 3)
12. The program became a founding member of the North African Seaturtle Network, which declared in July 2019 in Tunisia. This clip of Mr. Almokhtar Saied presenting on the LibSTP to the NASNET meeting in Tunis.

Chapter 2

Sex-ratio estimations of loggerhead sea turtle hatchlings in Libyan beaches

By Imed Jribi, Almokhtar Said, Salih Diryaq

1. INTRODUCTION

Globally, seven species of marine turtles are identified, all of them, except the Flatback turtle of Australia, are included on the Red List of the International Union for Conservation of Nature (IUCN), for species whose populations are in danger of extinction. These animals with a fascinating life must be protected through management at different periods of their life and at different areas of nesting, feeding, wintering grounds, and migration routes. It is, therefore, necessary to know their status and meet local, regional and international efforts to reach the goal.

In the Mediterranean, three marine turtle species are regularly observed: Caretta caretta (loggerhead turtle) which is the most common species spread in all marine areas, with important nesting sites in Greece, Libya, Turkey and Cyprus; Chelonia mydas (green turtle) which is basically restricted to the easternmost part of the Mediterranean, with nesting sites in Turkey, Cyprus, Lebanon, Egypt and Syria and Dermochelys coriacea (leatherback turtle) with no population at all in the Mediterranean but entering to the basin in small numbers from the Atlantic.

In Libya, nesting activity has been reported in the literature since the 1980s (Armsby, 1980; Schileich, 1987). The scientific studies specific to these species began in the mid-90s with national surveys of nesting sites. These prospections have put the item on the importance of nesting sites with nesting populations exceeding those of Turkey, Cyprus and would be equivalent or even larger than those of Greece (Laurent et al. 1997 and 1999).

Since 2005, the Libyan Seaturtle Program (LibSTP) was launched by the Environment General Authority in Libya (EGA) to monitor of the most important nesting beaches in order to protect beaches, nesting females and hatchlings and to determine eco-biological parameters necessary for any conservation activity (importance of nests, density of nests and hatching and emergence rates... etc.). These beaches are mainly those of Al Gbeba, Althalateen, to the west of sirte, beaches South of Bengazi, Ain Alghazala, Kouf National Park, and Between Misurata and Sirte which should be considered major mediterranean nesting sites for Caretta caretta (Hamza and Elgmati, 2006, Hamza, 2007; Saied, 2008).

Recalling the articles of the SPA protocol and the revised action plan on marine turtles in the Mediterranean, and taking into account the new developments concerning conservation measures based on scientific basis, furthermore considering the potential effects of global warming on future population structure and its implications on dynamics of these endangered species, we tried to investigate the trends of sex-ratio of hatchlings in the most important nesting sites of Libya. We started by the beaches of Sirte in 2009 and Misratah in 2010 but unfortunately the study in Misratah could not be terminated because of the war during the Libyan revolution.

Sex determination is the initial event where undifferentiated gonad opts for one lane of ovarian or testicular differentiation. In mammals, for example, sex determination is genotypic (GSD for Genotypic Sex Determination) with heterogametes (XY) for male and homogamets in females (XX). In marine turtles like all crocodilians and some squamata, sex determination is sensitive to the incubation temperature of eggs (TSD for temperature-dependent Sex Determination) (Yntema and Mrosovsky, 1980 for example).

In marine turtles, sex depends on the proportion of time at temperature during the thermosensitive period (TSP), which is the middle third of the incubation duration (Mrosovsky and Pieau, 1991). A theoretical constant pivotal temperature produces a 50 % male/female ratio of hatchlings (Mrosovsky and Yntema, 1980) and within a small transitional range of temperature (TRT), cooler temperatures produces more males and warmer temperature more females (Mrosovsky and Pieau 1991).

Additionally, in marine turtles there is no sexual dimorphism to distinguish between the two phenotypes males and females in hatchlings and juveniles. Only adult males acquired a long tail permitting to distinguish them.

The determination of sex and hence the sex-ratio of hatchlings is very significant in all conservation measures of marine turtles because it affects the sex ratio in the population and affects the reproductive success (Hanson et al. 1998). It should therefore be taken into account in any conservation activity on nesting beaches in order to conserve the «sexual structure» of the population and act in an appropriate manner for the protection of these endangered reptiles especially in the context of current global warming. Indeed, in some species, we pass from 100 % males to 100 % females in less than 0.5 °C while the average warming predicted on a scale of 100 years is 2 °C.

In this part of the report, we present results of the estimation of sex-ratio in the beaches near Sirte (Al Gbeba, Althalateen, Shash, Al-Arbaeen and West Camp).

2. MATERIAL AND METHODS

2.1. Study site

The Libyan coast extends to about 2000 km. Most of this coast is still in pristine condition; not only due to the limited human activities, but because of the underdeveloped fishing industry of Libya, compared to neighbouring countries (Laurent et al., 1996).

The fieldwork in 2009 was conducted in the beaches of Al Ghbeba, Althalateen, Shash, Al-Arbaeen and west of Althalateen. During 2010, the beaches selected were those of Musratah. All these beaches (Figure 2.1) were located in the gulf of Sirte which has a total length of more than 800 km.

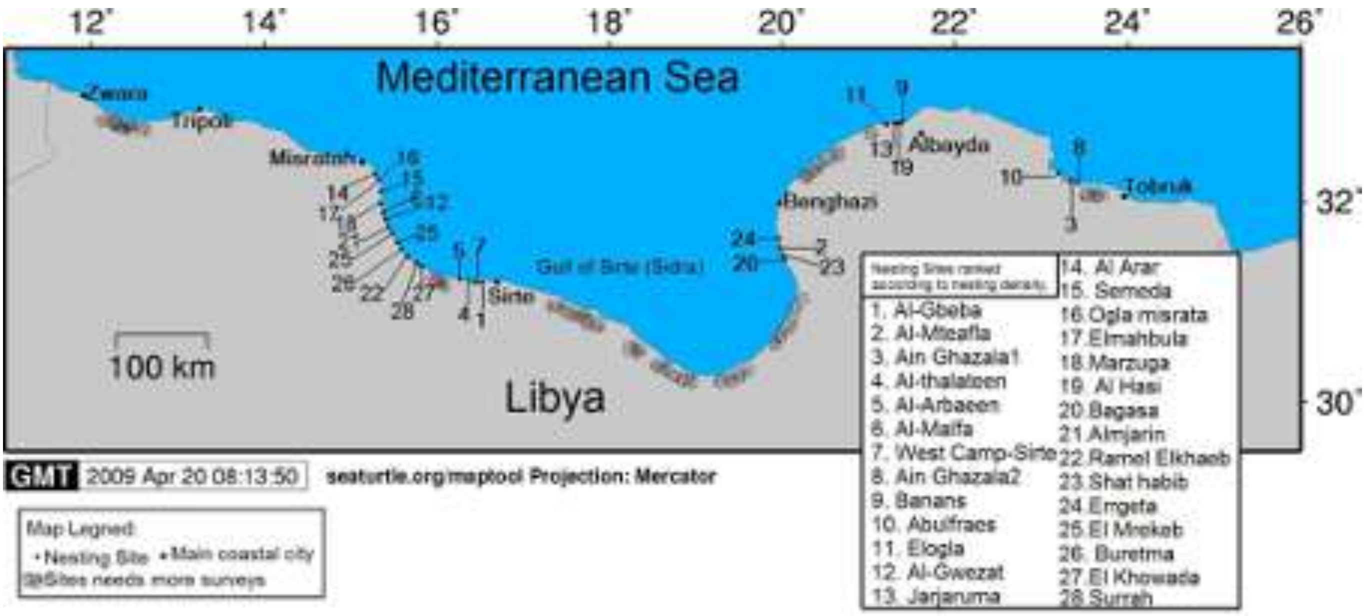


Figure 2.1: Map of nesting sites along the Libyan coast.

2.2. Nest data collection

Nesting and hatching activity were observed over the beaches as part of the long-term monitoring program undertaken by EGA since 2005. Each nest was located by walking on the beach and the precise GPS position was registered. Nests chosen for the sex-ratio study were protected by under-sand wire netting to deter predators. Nest distance from the sea was recorded from the nest location to the sea-line. For the purpose of this study, incubation duration is defined as the period in days between observation of the newly laid nest and the first record of hatching emergence, by either direct observation of hatchlings or their crawl tracks on the beach.

2.3. Temperature and incubation duration data collection

Temperatures in 14 loggerhead turtle nests were examined using electronic LogTag HAXO-8 Humidity and Temperature Data Logger (LSTechnology, UK) during July-September 2009 nesting season in the beaches of Al Ghbeba, Althalateen, Shash, Al-Arbaeen and West Camp located in the gulf of Sirte.

The 14 nests were selected as being representative of the beach. Temperature data loggers were placed into the centre of the nests before the starting of the second third of the incubation duration. All loggers were programmed to record a reading every 15 minutes.

The middle third of the incubation period was calculated based on an incubation time defined as the number of days from the date of eggs deposition to the date of the first emergence.

2.4. Estimating sex-ratio

The sex-ratio of hatched loggerhead turtles were estimated using two methods: The first used the mean temperature during the middle third of the incubation period and the second used the incubation duration. The curves of sex-ratio as functions of incubation duration and sex-ratio as function of temperature during the second third of incubation duration were those of Mrosovsky et al. (2002) adapted to the field. The curve of sex-ratio as a function of the mean temperature during the second third of incubation duration was adapted to the field by adding 0.4 °C which correspond to the difference between ambient temperature and eggs temperature (Mrosovsky et al., 2002) (Figure 3.2) and the curve of sex-ratio as a function of incubation duration (Mrosovsky et al., 2002) was also adapted to the field by adding 4 days which correspond to the interval between hatching and the emergence of hatchlings at the sand surface (Godfrey et al., 1997) (Figure 2.3).

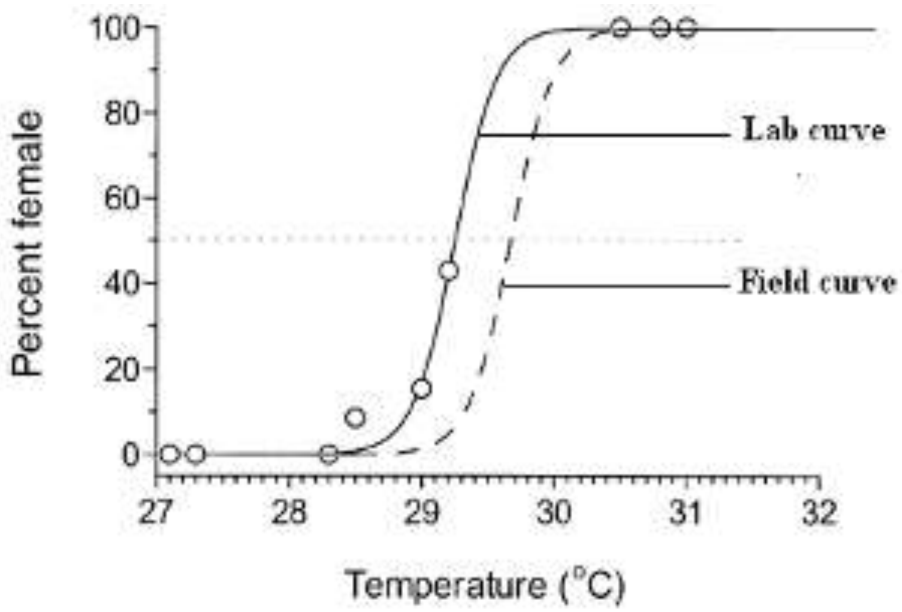


Figure 2.2. Percent female as a function of temperature (Mrosovsky et al., 2002) adapted to the field

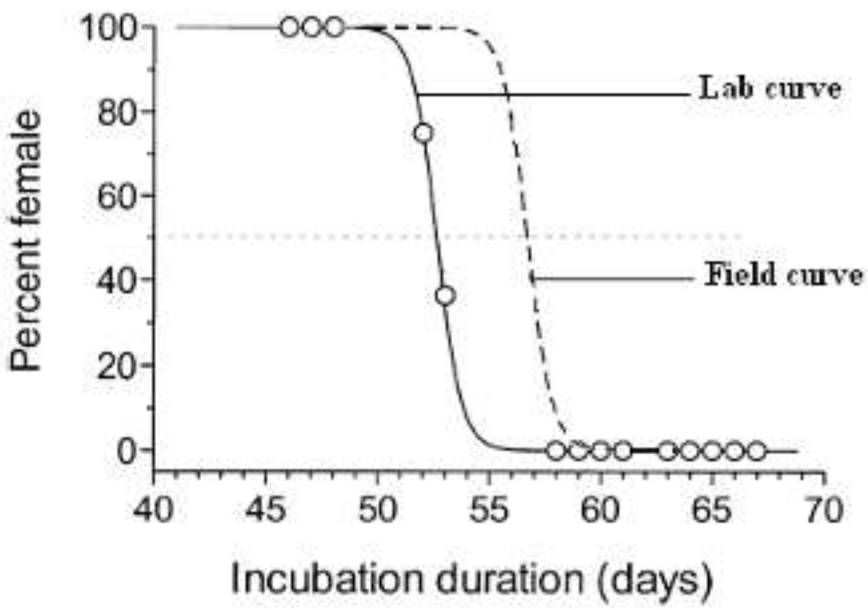


Figure 2.3. Percent female as a function of incubation duration (Mrosovsky et al., 2002) adapted to the field.

3. RESULTS AND DISCUSSION

During the 2009 nesting season, 358 nests were recorded in about 25km of controlled beaches in Sirte. The nesting density varied between 9.02 nests/km to 21.65 nests/km with a mean of 14.45 nests/km.

All 14 nests studied here were recorded during July. In all nests, the Humidity and Temperature data logger were placed before the beginning of the second third of incubation duration. These data loggers were distributed to all beaches in order to cover the entire nesting site (3 in Al Ghbeba, 2 in Al-Thalatheen, 2 in West Al-Thalatheen, 4 in Shash and 3 in Al-Arbaeen).

The data loggers, in the studied nests, worked well in 13 nests. Therefore the nest where the logger didn't work was excluded from our discussion.

The information on the temperature and humidity recorded in studied nests is presented in Table 2.1 and 2.2 respectively.

Table 2.1. Information on average temperature in studied nests during different periods of incubation

Nests	Temperature			
	Total IP*	First third IP	Middle third IP	last third IP
1	29,9	29,4	29,9	30,2
2	29,8	29,1	29.5	30,3
3	29,1	28,7	29.2	29,3
4	31,2	30	31,3	31,8
5	30,2	29,1	29,9	31
6	30,3	29,1	29,8	31,2
7	?	29,2	29,7	?
8	29,9	29,1	29,9	30,3
9	32,1	30,3	31,8	32,5
10	29,5	28,6	29	30,3
11	31,3	30	30,6	32,2
12	30,4	29,2	30,3	31,5
13	30,6	29,4	30,3	31,8

*IP: Incubation period

Table 2.2. Information on average Humidity in studied nests during different periods of incubation.

Nests	Humidity			
	Total IP	First third IP	Middle third IP	last third IP
1	94,9	100	100	81,8
2	94,1	99,8	100	87,4
3	100	100	100	100
4	100	100	100	100
5	100	100	100	100
6	100	100	100	100
7	100	99,9	100	100
8	100	100	100	100
9	99,9	97,6	100	100
10	100	100	100	100
11	59,2	100	97,8	10,8
12	85,2	100	100	57,1
13	95,2	100	100	85,7

The mean temperature of the whole incubation period for the 13 nests ranged from 29.1 to 32.1 °C. The maximum temperature increase during the incubation period was 5.3 °C.

The mean temperature during the middle third of the incubation ranged from 29°C (Nest 10) to 31.8 °C (Nest 9). The maximum temperature increase during this period was 3.5 °C (for nest 9 : minimum of 30.2 °C, maximum of 33.7 °C). The minimum temperature increase was 0.6 °C (Nest 3: minimum of 28.9 °C, maximum of 29.5 °C).

The mean temperature during the incubation period increases in the middle third of the incubation compared to the first third and continues to increase during the last third.

Regarding the humidity, it seems that the air in the nests is saturated with water. However we can notice a decrease just before the emergence what could indicate about the hatching and the approximation of the emergence. This fact should be investigated further.

The sex-ratio of hatchlings for all nests was estimated according to the incubation duration and to the nest temperatures during the middle third of incubation duration based on the curves elaborated in the laboratory by Mrosovsky et al. (2002) and adapted to the field. The choice of the study of Mrosovsky et al. (2002) is based on the fact that turtles from Greece and those of Libya are part of the same Mediterranean population and have the same geographic range. The estimation results are shown in Table 2.3 for each nest.

Table 2.3.Information on nests, incubation duration and temperature data with the estimated sex ratio (%♀)

Nest	Beach	Lay date	Clutch size	ID*	T° (Middle third ID)	Sex ratio (%♀)	Sex ratio (%♀) from T°
1	Al-Arbaeen	31 July	69	50	29,9	100	80
2	Shash	13 July	45	52	29.5	100	25
3	West Camp	25 July	45	58	29.2	10	5
4	Al-Thalatheen	17 July	33	51	31.3	100	100
5	Al-Thalatheen	11 July	105	47	29.9	100	80
6	Shash	10 July	86	54	29.8	100	70
7	Al-Arbaeen	09 July	75	55	29.7	95	54
8	Shash	21 July	39	57	29.9	40	80
9	Al-Arbaeen	06 July	63	52	31.8	100	100
10	West Camp	16 July	74	56	29.2	75	5
11	Al Ghbeba	06 July	69	49	30.6	100	100
12	Al Ghbeba	20 July	79	51	30,3	100	100
13	Shash	22 July	91	47	30.3	100	100
Mean			**68.9**	**52.2**		**86.2**	**69.2**

ID* Incubation duration

The mean sex-ratio based on incubation duration is 86.2 if nests were taken one by one. If we consider the mean incubation duration of the 13 nests studied together, the sex-ratio will be 65 % which is nearest to the sex-ratio estimated by temperature.

Of the 13 nests, 11 were predicted to produce more females with proportions near 100 % of females for the majority if the estimation is based on incubation duration.

If based on temperature during the second third of incubation duration, 9 were predicted to produce more females, three were predicted to produce more male and one was predicted to produce hatchlings with a sex ratio near of 1:1. Comparison of the two methods indicates that sex ratios are not significantly different ($P < 0.05$).

The common pattern of sex ratio for loggerhead marine turtles in the Mediterranean region is generally female dominated (Kaska et al., 1998 and 2006; Öz et al., 2004; Rees and Margaritoulis, 2005; Godley et al., 2001). The results of our studies indicate that Sirte beaches are also areas producing a female-biased sex ratio.

Having stated that primary sex ratio of hatchling production was female biased, two factors must be taken into account that might alter this ratio: The effects of nest inundation and the effects of nest predation.

Nest inundation has been shown also to increase incubation duration and is suggested to possibly play a significant role in masculinisation of turtle hatchlings (Rees and Margaritoulis, 2005). Data analysed should take incubation duration of inundated nests into account.

Nest predation is also known to have effects on the sex-ratio of hatchlings that emerge from the nest and reach the sea. The longer the incubation period, the greater the chances of that nest being predated. Kaska (2000) states that « smell and activities of the first group(s) of hatchlings may provide clues for predators about the location of a nest, and those emerging toward the end of the hatching duration are threatened most ». If nest temperatures are higher at the top as shown in some studies (Kaska et al., 1998; Jribi et al., 2008), there is an increased chance of predation of female hatchlings that would be in the nest top and the first ready to leave it. Nest predation represents a major threat in Sirte beaches (Hamza and Elghmati, 2006) especially when conservation practices are not fully in place, therefore would be an important factor affecting the loggerheads sex-ratio.

In conclusion, although a female-biased primary sex-ratio of hatchling production is indicated, results are only preliminary and much improvement is needed in the next years. The coverage of the whole nesting period and sampling other nesting sites in Libya, which might have different climatic conditions, are necessary and the factors that may alter the ratio such as inundation and predation should be considered and further assessed.

Chapter 3

Identification of migration corridors and marine areas for Loggerhead Turtles nesting in West Sirte

By Flegra Bentivegna, Sandra Hochscheid, Abdulmaula Hamza,
Almokhtar Said and Salih Diryaq

1. INTRODUCTION

The effective protection of the endangered Mediterranean loggerhead turtle, Caretta caretta, requires knowledge about their habitat preferences and behaviour during the various life stages, thus to design and revise specific conservation plans. The identification of mating, feeding and wintering areas and key migration passages were on the top of the research priorities in the action plan for the conservation of Mediterranean marine turtles (UNEP MAP RAC/SPA, 2007). Hence, studies on turtle movements and behaviour at-sea have been encouraged and supported by the RAC/SPA all over the Mediterranean, and in particular, since 2001 in collaboration with the Marine Turtle Group of the Stazione Zoologica Anton Dohrn of Napoli, Italy, because of their expertise in the satellite tracking of marine turtles (Bentivegna 2002, Bentivegna et al. 2008, Bradai et al. 2009, Hochscheid et al. 2011).

A comprehensive review of over 130 scientific papers on sea turtle tracking studies highlighted the knowledge on temporal and spatial movement patterns, habitat use, post-release survival following fisheries interaction and rehabilitation, and critical areas for conservation (Godley et al. 2008). It was also clearly revealed that there are biases in the wealth of data, particularly concerning the geographic region, species and life stages. The authors summarised that 82% of the satellite tracking studies included only three species (Loggerhead, Green and Leatherback turtles), and >75% were conducted on adult females. About 11% of the worldwide turtle tracking was carried out in the Mediterranean. These figures have likely changed until today, but tracking efforts in the Mediterranean is proportionally well represented with respect to other geopolitical regions and provides essential information for conservation management (Hays & Hawkes 2018). However, although the importance of the Libyan coasts is now well documented for both turtles feeding and overwintering in the coastal waters (Godley et al. 2002, Broderick et al. 2007). In addition to LibSTP efforts to monitor nesting activity on the beaches (see chapter one of this book), nothing is known about where these turtles go after nesting (see also (Casale et al. 2018) for a more recent review on marine turtle marine areas in the Mediterranean).

(Broderick et al. (2007) found that both green (Chelonian mydas) and loggerhead turtles, that nest in the eastern Mediterranean beaches, showed fidelity to the foraging and overwintering areas in the Gulf of Sirte (W Libya) and and Bay of Bomba (E Libya), such habitats may be suitable for the Libyan nesting population as well. Yet, a recent study using a combination of satellite tracking and oceanographic modelling has shown that the pattern of adult turtle dispersion from a breeding area in Greece reflects the extent of passive dispersal that would be experienced by hatchlings (Hays et al. 2010, Casale & Mariani 2014). Therefore, the prevailing currents around nesting areas are crucial to the selection of foraging sites used by adult marine turtles. Thus turtles nesting in Libya may prefer foraging grounds that they have come first in contact with during juvenile dispersal.

In the light of this knowledge, the satellite tracking of loggerhead turtles nesting in Libya was initiated to detect the marine areas frequented by these turtles for foraging and overwintering and to elucidate the spatial and temporal existence of migratory corridors that connect these habitats.

2. MATERIALS AND METHODS

2.1. Field Work

Two Satellite tagging activities were conducted during 2009 and 2010, in a collaboration between the Libyan Seaturtle Program (LibSTP), the Stazione Zoologica of Napoli (SZN) and RAC/SPA (MoU N° 53-RAC/SPA-2009, MoU N° 88-RAC/SPA-2009, and MoU N° 21-RAC/SPA-2010) in the periods from 19 – 25 July 2009 and 5 – 11 July 2010. The fieldwork conducted during the nesting monitoring activities of the Libyan Sea Turtle Program (LibSTP) in the west Sirte region. During the first mission in 2009, three female loggerhead turtles were equipped with satellite transmitters, one in Misurata (32.383°N, 15.056°E) and two in Sirte (31.206°N, 16.588°E). In 2010 two further turtles that nested in Sirte were equipped.

2.2. Satellite Transmitter Deployment

Satellite transmitters used in this study were of the type TAM 4410 (n = 3) and TAM 4525 (n = 2) (Telonics, Meta, Arizona, USA). The first turtle (A), equipped in Misurata, was kept in a cage in water after she finished nesting and was released in the morning after the transmitter attachment. All other turtles (B – D) were located during night patrols on the beaches near Sirte that were carried out by the team of LibSTP. Once a turtle was sighted laying eggs, it was left alone until it had covered up the egg chamber and body pit. Before tag attachment, the turtles' curved carapace length and width were measured with a flexible meter tape, and the turtles were tagged in the front flippers. Each turtle was held in place by up to four persons while the transmitter was attached to the carapace. First, an area of ca. 30 cm diameter around the second central scute was sandpapered and then cleaned thoroughly with Acetone. Then a small quantity of fast setting epoxy glue (Pure K2, PowerFasteners, NL) was applied to the thus prepared carapace, and the transmitter was placed on top. Careful application of the second layer of epoxy glue was carried out to cover parts of the transmitter itself and the area around the device. The whole procedure took approximately 60 min. When the glue was hard to the touch the turtles were released and immediately re-entered the sea.

2.3. Transmissions and data handling

Transmissions were received through the ARGOS system (www.argos-system.com). Only transmissions where the turtles spent enough time at the water's surface, allowing at least two uplinks to reach the satellites, resulted in the calculation of a location. Locations are delivered with 6 classes of quality, in order of descending quality: 3 (<150 m), 2 (150 – 350 m), 1 (350 – 1000 m), 0 (>1000 m), A, and B. For the latter two, no level of accuracy is assigned by ARGOS. Data for all turtles were uploaded into the Satellite Tracking and Analysis Tool (STAT, Coyne and Godley, 2005) and made visible on the tracking website of seaturlte.org, under the project name RAC/SPA – SZN Tracking of Mediterranean Marine Turtles (http://www.seaturtle.org/tracking/?project_id=358).

To reconstruct the post-nesting migration routes, all location classes were used since the majority of locations were of class B and the number of high-quality locations (3-1) was not sufficient to map the migration route. However, to obtain the most likely path travelled by the turtles, a filter was applied that eliminated all locations for which travel speeds exceeded five kmh-1, and the turning angle between two legs connecting three successive locations was less than 30°, indicating improbable course returns. The same data filtering procedure was followed for the locations received from the turtles' residence sites. The beginning and end of migration, summer and winter residences were extracted from the data by plotting displacement from the deployment site (Figure 3.1). Migration was considered to have ceased when displacement began to plateau; likewise, summer and winter residences were considered to have ended when displacement values started to change again. Filtered location data in residence areas were used to construct approximate home ranges for each turtle when sufficient positions were available. However, due to the uncertainty of location class B positions a detailed home range analysis was not attempted this time. Therefore, the approximate maximum extension of the turtles' residence areas was estimated first by drawing polygons through the outermost positions that encompassed all other locations received for a specific area and second, by determining the maximum distance across these polygons. These operations were carried out with the Google Earth software (Google Inc. 2011).

All maps in this paper were made using the Maptool software by seaturtle.org (http://www.seaturtle.org/maptool/). The Maptool also allowed to include layers of bathymetry (from the GEBCO Digital Atlas or ETOPO2 Global 2' Elevations datasets distributed by the British Oceanographic Data Centre and NOAA's National Geophysical Data Center) and monthly average sea surface temperatures (derived from NOAA's AVHRR SST satellite data).

3. RESULTS

3.1. Post-nesting migration

General information on the tracking of female loggerhead turtles from Libya is summarised in Table (3.1). Three of the five equipped turtles departed immediately on their post-nesting migration (Turtles B – D). In contrast, turtle A remained for 19 days in the vicinity of the beach at Misurata and turtle E for 15 days in the Sirte area before they set on their migration. It is most likely that both turtles stayed to make at least one more nest. After leaving the nesting ground, all turtles headed in the same general direction westward along the north coast of Libya (Figure 3.2). Turtles B, D and E stayed relatively close to the beach on their migration in waters less than 100 m deep, while turtles A and C travelled farther offshore in waters exceeding 200 m depth. The females took between 11 and 19 days to arrive at their destinations, spanning a total distance that ranged between 310 and 641 km at an average rate of 36 km d-1. The post-migration stopped when the turtles remained in the same area for at least 30 days, and the daily distances moved decreased to <30 km d-1. The turtles settled in four different areas: 1) ca. 30 km off the northern coast of Libya, halfway between the Tunisian-Libyan border and Zuwārah (LY) (32.931°N, 12.093°E) (Turtle A); 2) offshore on the Tunisian Plateau midway between the Iles Kerkennah (TN) and Lampedusa Island (IT) (Turtle C); 3) in the northern Gulf of Gabés (TN) (Turtles B, E); 4) in the Gulf of Boughrara (Djerba, TN) (Turtle D) (Figure 3.2).

3.2. Seasonal migration

Four of the five turtles (Turtles A, C – E) were tracked long enough to follow them into the winter period, three (Turtles C – E) of them left the summer foraging area to overwinter at another site. Turtle C started this seasonal migration on 30 November 2010, and the first location on the overwintering site off the coast of Libya was received on 28 December 2011. However, due to a lack of transmissions in that period, the migration route could not be reconstructed, and we cannot estimate how long it took the turtle to travel between the summer foraging ground and the winter site (a minimum distance of 206 km) (Figure 3.3). Turtle D left the summer residence area in the Gulf of Boughrara sometime after 19 December 2010, and the next available location on 29

December was already outside the Gulf, north of Djerba, at a minimum distance of 54 – 75 km (depending on the path the turtle took around Djerba) (Figure 3.3). As for Turtle D, no migration route between the two residence sites could be reconstructed due to the lack of location data. The only turtle for which a location during the seasonal displacement was available is Turtle E. It left its summer area on 22 October 2010, passed close to Djerba Island on 23 October 2010, on an eastward movement and arrived at the winter site off the Libyan coast on 25 October 2010, after travelling a minimum distance of 168 km (Figure 3.3). The behaviour of Turtle A differed from that of the others. She left the first residence site in Libyan territorial waters after one month at the beginning of September 2009 and, after a three-week northwest looping movement the turtle finally settled in an area less than 30 km distant to the first area, but closer to the Libyan coast (Figure 3.3).

For one turtle the transmissions continued long enough to record also her return to the summer foraging area at the beginning of the spring (between 5 and 8 April 2011). Some locations on the route were available to reconstruct an approximate migration path (Figure 3.4). She arrived at the summer residence site between 24 and 27 April, thus after a maximum of 22 days.

3.3. Summer and winter residence sites

Four of the five female loggerhead turtles were tracked on the foraging area for at least one month. As described above, three of these turtles stayed until late autumn/beginning of winter before they left the area. While on the foraging ground, the displacement, in respect of the release location did not change anymore (see plateau phases in Figure 3.1) and the turtles remained within relatively small areas with a maximum extension of 35 km. The effective home range is probably much smaller, but could not be estimated for this study, for reasons explained in the materials and methods.

The foraging ground of Turtle C was farthest offshore with a mean distance to the shore of 59 km. In comparison, Turtle D remained closest to the coast (mean distance to shore 8 km), within the Gulf of Boughrara which is surrounded by land and communicates with the sea only via two narrow passages in the northwest and northeast between mainland Tunisia and Djerba (Table 2).

Over the entire tracking period, turtles generally stayed in areas on the continental shelf with relatively shallow water depths: Turtles D and E mainly remained in waters with up to 25 m maximum depth, while Turtles A – C resided in areas with sea floor depths between 25 and 50 m (Figure 3.5). Water depths >50 m were mostly encountered on their migrations, and for this reason turtle B appeared to have frequented deeper waters since the tracking of this turtle only encompassed the post-nesting migration phase.

Since the turtles changed their residence area between summer and winter, there were also changes in sea floor depths at the respective sites (Tables 3.2 and 3.3). During the winter period all turtles for which sufficient data were available, mostly stayed in waters equal or shallower than 25 m (Table 3.3). In contrast, zones during summer foraging included also deeper waters (Table 3.2).

Figure 6 shows the mean monthly sea surface temperatures (SST) for the foraging and winter sites. In the late summer, temperatures were warmer towards the land (28°C) but overall there was little difference between the various foraging areas. Turtle E was the first to leave the summer foraging area and move to its winter site, where mean sea surface temperatures were at least 2°C higher. The turtle was followed by Turtle C and then by Turtle D, the latter of which, however, moved only a short distance to settle outside Boughrara and north of Djerba. Monthly mean SST in January was warmer at this location with respect to the Gulf of Boughrara (Figure 3.6e), and also the other turtles had moved to sites which were 1 – 2°C warmer in the winter than their foraging areas (Figure 3.6 e, f). Thus turtles overwintered in waters of 16 – 17°C and when Turtle C finally moved back to the foraging area in the spring, temperatures there had risen on average to 17°C again (Figure 3.6h).

4. DISCUSSION AND CONCLUSIONS

Satellite tracking is a powerful tool to investigate the movements and habitats of migratory marine species and have yielded significant results that may otherwise have been uncovered. Marine turtles are an excellent animal model for the deployment of modern telemetry devices since tags can be simply glued onto their hard shell and they come on land for nesting, thus making them easy to access. However, once a turtle equipped with a satellite tag re-enters the sea, the success of the tracking and fate of the transmitter is subject to various hazards (e.g antenna damage, battery or sensor failure, see (Hays et al. 2007). Permanent transmission failure is thus only in some cases linked to the death of the turtle. Such may have been the case for turtle B, for which transmission abruptly ceased immediately upon arrival in her putative foraging area in the northern Gulf of Gabés. However, neither turtle nor transmitter have ever been recovered, so any reasoning on the turtle's fate is purely speculative.

Tracking of the other turtles lasted on average long enough to establish both summer and winter residence sites. Despite the availability of suitable foraging and winter areas in the vicinity of the nesting beaches in west Sirte, all turtles left their nesting grounds and travelled to the vast Tunisian Plateau. During this post-nesting migration, turtles travelled westwards close to the Libyan coast. This behaviour shows the existence of a migratory corridor which is used only in short time windows (late July/August) and also by turtles departing from other nesting beaches (e.g. Cyprus (Broderick et al. 2007) and Turkey (RAC/SPA, unpublished data)).

The Tunisian Plateau, and particularly the Gulf of Gabés area has already been identified as an important foraging and winter site for turtles nesting in other Mediterranean regions such as in Greece (Margaritoulis et al. 2003, Zbinden et al. 2008), Cyprus (Broderick et al. 2007, Snape et al. 2016), Turkey and Tunisia itself (RAC/SPA, unpublished data). Data about the bathymetry at the individual foraging areas confirm that the turtles inhabited neritic foraging sites and most likely feed on benthic organisms since the seafloor was well within the depth of their diving capacity (Hochscheid et al. 2007). Diet analysis on loggerhead turtles captured in this area has also revealed that these turtles mainly feed on benthic invertebrates (Laurent & Lescure 1994) and is in conformity with the general feeding ecology of adult loggerhead turtles in the Mediterranean (Casale et al. 2018, Jribi et al. 2008).

The residence sites chosen by the Libyan turtles can also be designated as summer foraging areas because interestingly, the turtles did not remain at these sites during the winter but moved all to other areas. Seasonal movements between summer foraging sites and winter sites have previously been reported for adult loggerhead and green turtles in the Mediterranean, although these movements were of short distance, where turtles moved to deeper waters during the winter (Broderick et al., 2007). Also, loggerhead turtles in Atlantic waters of the United States undergo seasonal migrations (Hawkes et al. 2011), and there is evidence, that some prefer warmer offshore areas where the Gulf Stream passes (Hawkes et al. 2007). Likewise, the Libyan turtles seemed to prefer warmer sites during the winter. They avoided the colder areas in the Gulf of Gabés where turtles can experience rather cold temperatures (<12 °C, (Hochscheid et al. 2007). It may be possible that seasonally declining water temperatures, likely also in combination with other environmental factors, trigger the turtles' movements towards warmer winter sites.

The results highlight once again the importance of the Tunisian plateau as both foraging ground and overwintering area, where turtles from multiple Mediterranean origins mix. Unfortunately, this area is also known to be heavily exploited by fisheries. It has been estimated, that Tunisian fisheries alone capture about 24,000 turtles per year, with almost 11,000 only in bottom trawls (Casale 2011), half of which are caught in the Gulf of Gabés (Jribi et al. 2007, Jribi et al. 2008). Bottom trawlers are the most impacting fisheries type on loggerhead turtles in their neritic foraging grounds on the Tunisian Plateau because both fisheries and turtles use the resources on the seafloor. Hence, there is a high interaction probability. This situation calls for urgent conservation measures to reduce the demonstrated high mortality in fishery's bycatch.

In comparison to large juvenile loggerhead turtles that also use the Tunisian continental shelf to forage (Casale et al. 2012), adult loggerhead turtles tracked here had much smaller and better-defined home ranges (see also Snape et al. 2016). Yet, with the current small sample size and the distances between the selected foraging sites, there was no overlapping between these sites. This makes it challenging to identify high-use zones in which conservation efforts should be concentrated. The Tunisian Plateau is a vast area, and for protection plans to be effective and practicable, some key zones with high turtle densities need to be identified for conservation management. The unexpected outcome of this first tracking study of Libyan loggerhead turtles was the presence of a well-defined winter site at the Libyan-Tunisian border, where three out of four turtles converged again after separating on different summer foraging sites.

In conclusion, a further investigation of the habitat characteristics of this winter site and of the most likely hazards to the turtles during their residence would be necessary to work out a site-based conservation plan. Likewise, potential threats on the post-nesting migratory corridor along the north Libyan coast from Misurata to the Tunisian border will have to be identified and quantified, thus to act upon these and guarantee a save passage on this "turtle highway".

Table 3.1. Summary data for the tracking period of five loggerhead turtles

Turtle	CCL (cm)	Deploy Date	Release Location	At large (d)	No locations	Last Location
A (Hana)	70.5	20/07/2009	Misurata/Abu Fatma	367	182	22/07/2010
B (Maytiga)	81	22/07/2009	Sirte	17	42	08/08/2009
C (Sirt)	73	06/07/2010	Sirte/Alarbaeen	446	158	25/09/2011
D (Al-Guardabia)	74	07/07/2010	Sirte	235	77	28/02/2011
E (Al- Gbaiba)	72	06/07/2010	Sirte/Alarbaeen	182	394	04/01/2011

* correct with centroid for FG home range

Table 3.2. Summary data for Libyan loggerhead turtles' foraging grounds

Turtle	FG	Beeline* Dist. FG (km)	Travel time (d)	Travel rate (kmd^{-1})	Mean distance to shore (km)	Bathymetry (m)
A (Hana)	W Libya	316	11	28.7	45 – 25*	60 – 90
B (Maytiga)	N Gulf of Gabés#	644	17	37.9	n.a.	n.a.
C (Sirt)	Tunisian Plateau	586	19	30.8	59	45 – 50
D (Al Guardabia)	Gulf of Boughrara	556	14	39.7	8	<10
E (Al Gbaiba)	N Gulf of Gabés	644	15	42.9	13	15 – 20

n.a. not available

*this turtle moved to a site closer to the shore after only one month in the foraging ground.

#this is only a presumption since the transmissions for this turtle stopped there

Table 3.3. Summary data for Libyan loggerhead turtles' overwintering sites

Turtle	OS	Min Dist. FG - OS (km)	Mean distance to shore (km)	Bathymetry (m)
A (Hana)	W Libya	<30	25	20 – 25
C (Sirt)	W Libya	206	26	d.d.
D (Al- Guardabia)	S Gulf of Gabés	54-75	31	15 – 20
E (Al- Gbaiba)	W Libya	168	13	20 – 25

d.d. = data deficient, but the median value was 47 m

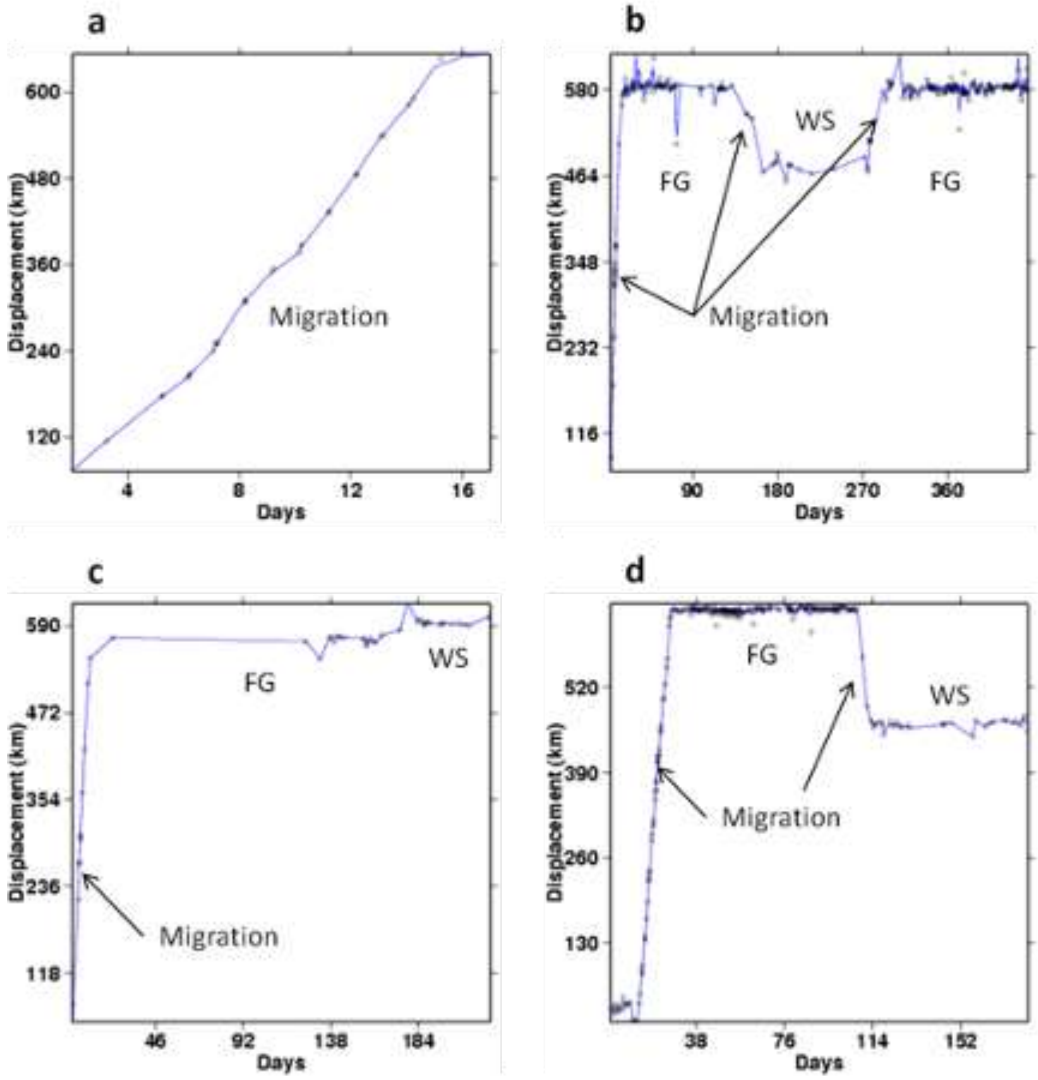


Figure 3.1. The displacement (km) with respect to the turtles' departure site at a given day during the tracking period.

Constant increases in the displacement occur during the migration away from the nesting beach, instead displacement decreases when the turtle travels towards the starting point again. Plateau in the curves indicated residence in a specific area (foraging ground [FG] or winter site [WS]). a) Turtle B, b) Turtle C, c) Turtle D, d) Turtle E. Note for Turtle B there is only the migration phase because the transmissions stopped when it arrived at the apparent foraging ground.

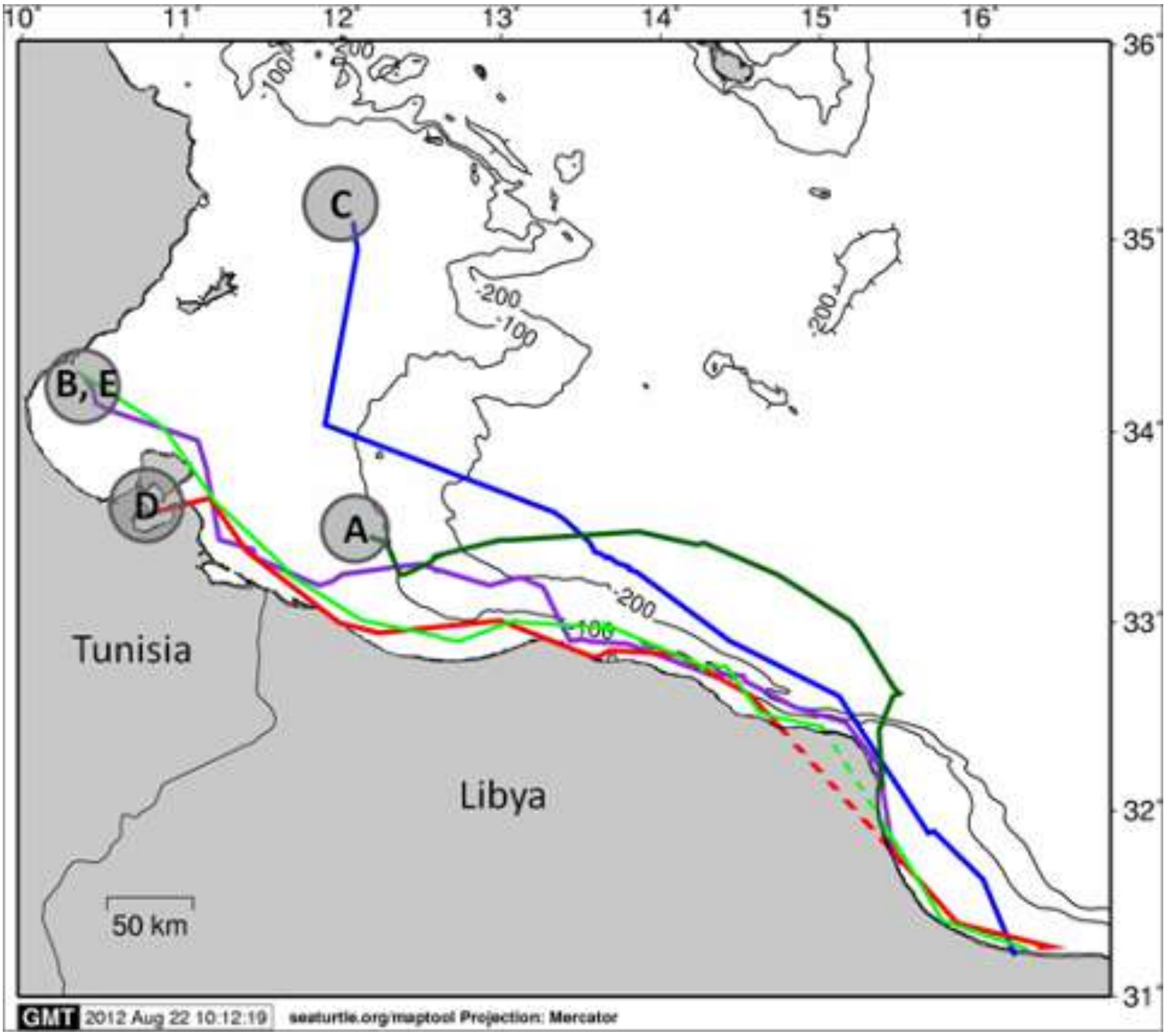


Figure 3.2. Figure 2. Reconstructed post-nesting migration routes of female loggerhead turtles leaving from Misurata (turtle A) and Sirte beaches (turtles B – E).

Each colour represents the track of a single turtle. Grey shaded circles indicate the general area of destination where turtles resided for the rest of the summer (except turtle B for which transmissions ceased, see main text).

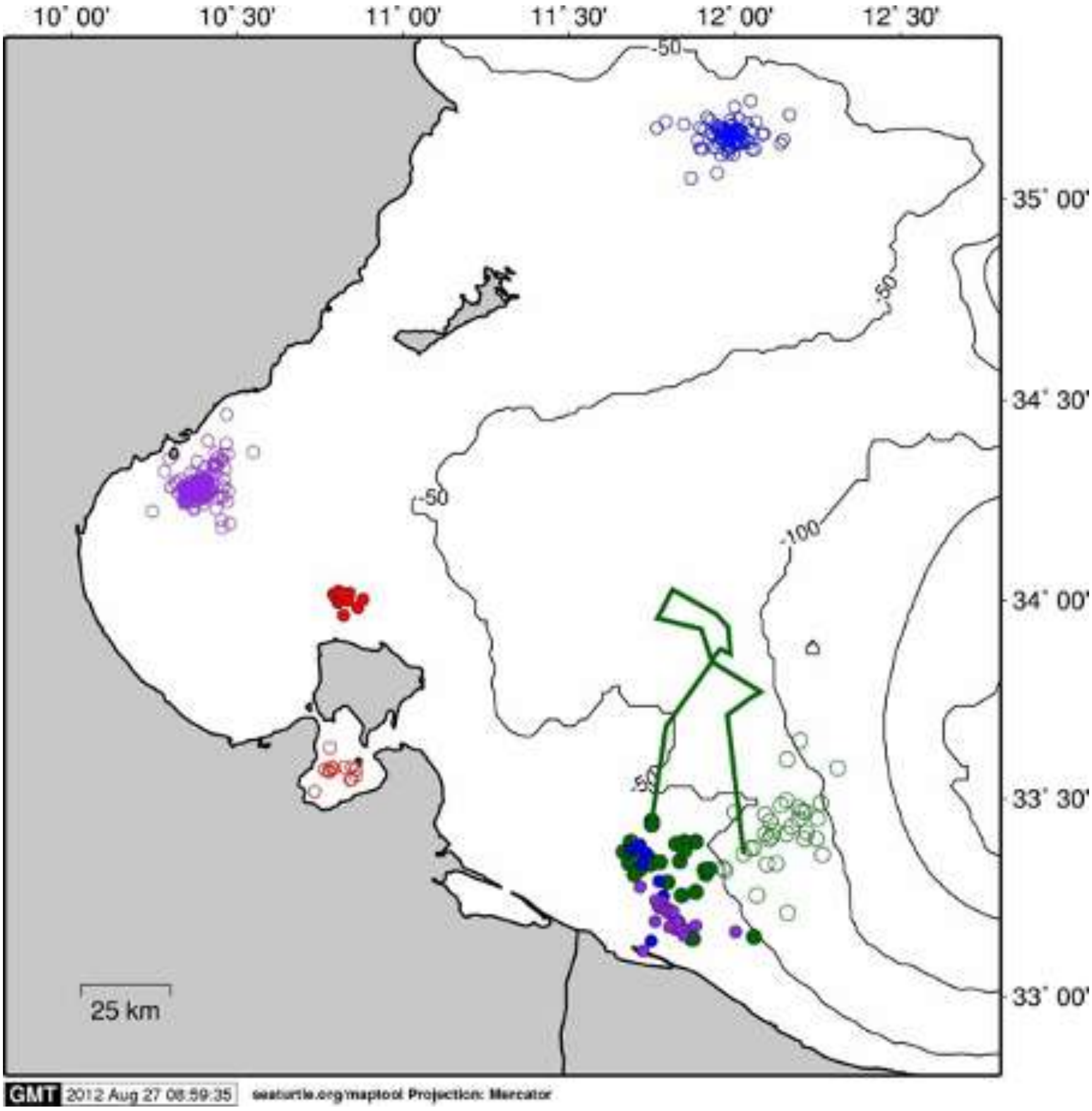


Figure 3.3. Summer foraging areas (open circles) and overwintering sites (filled circles) for 4 loggerhead turtles tracked after they left the nesting beach in west Sirte, Libya.

Different colours identify individual turtles (green = Turtle A, blue = Turtle C, red = Turtle D, purple = Turtle E). The solid green line indicates a northwest loop of turtle A that initially settled farther offshore and moved then into shallower waters where it remained through late summer and subsequent winter. Note: the residence area of Turtle A overlaps with overwintering sites of Turtles C and E.

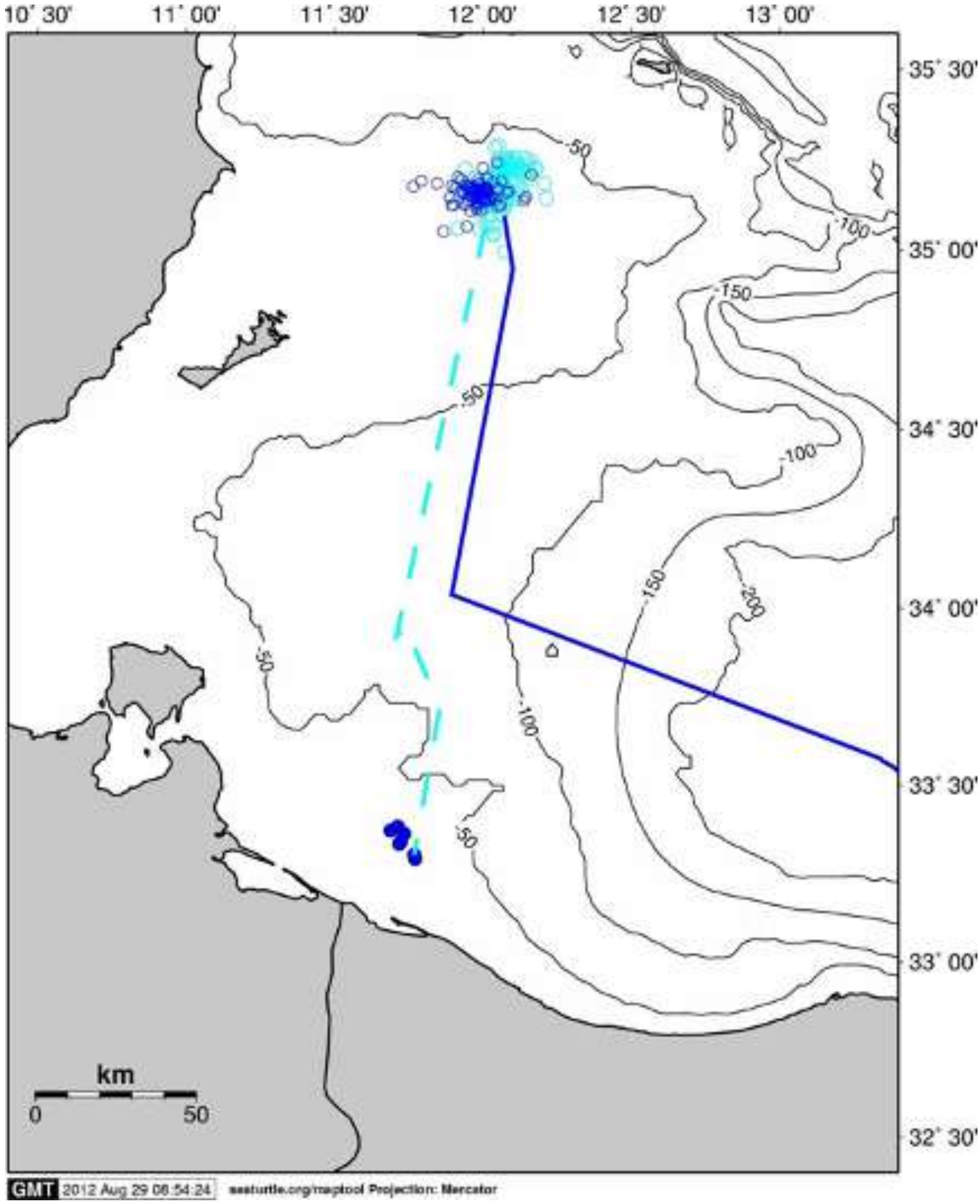


Figure 3.4. Reconstructed movements and residence sites for Turtle C: after leaving the nesting beach in Sirte the turtle migrated (dark blue line) into Tunisian territorial waters and went to its first residence area (open dark blue circles).

At the beginning of December 2010, it went south (no route is shown) to its overwintering site (filled dark blue circles). In the spring it travelled back (dashed light blue line) to its previous residence area (open light blue circles).

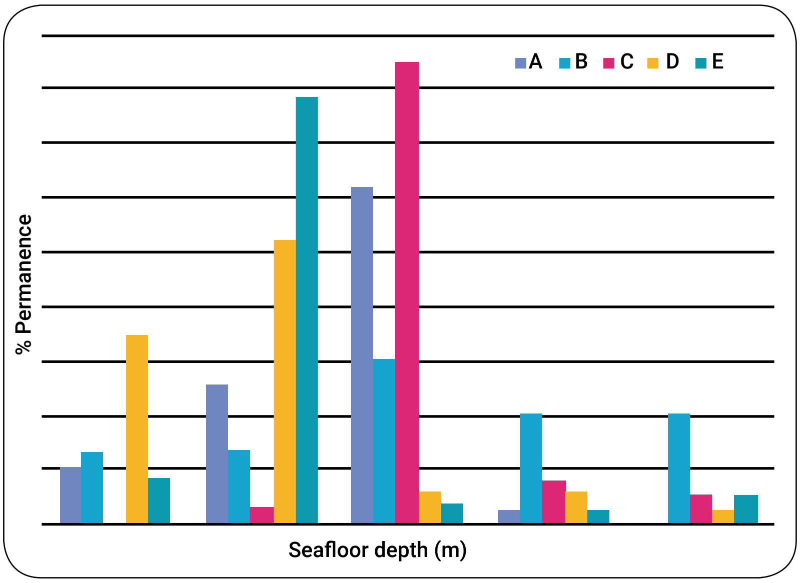
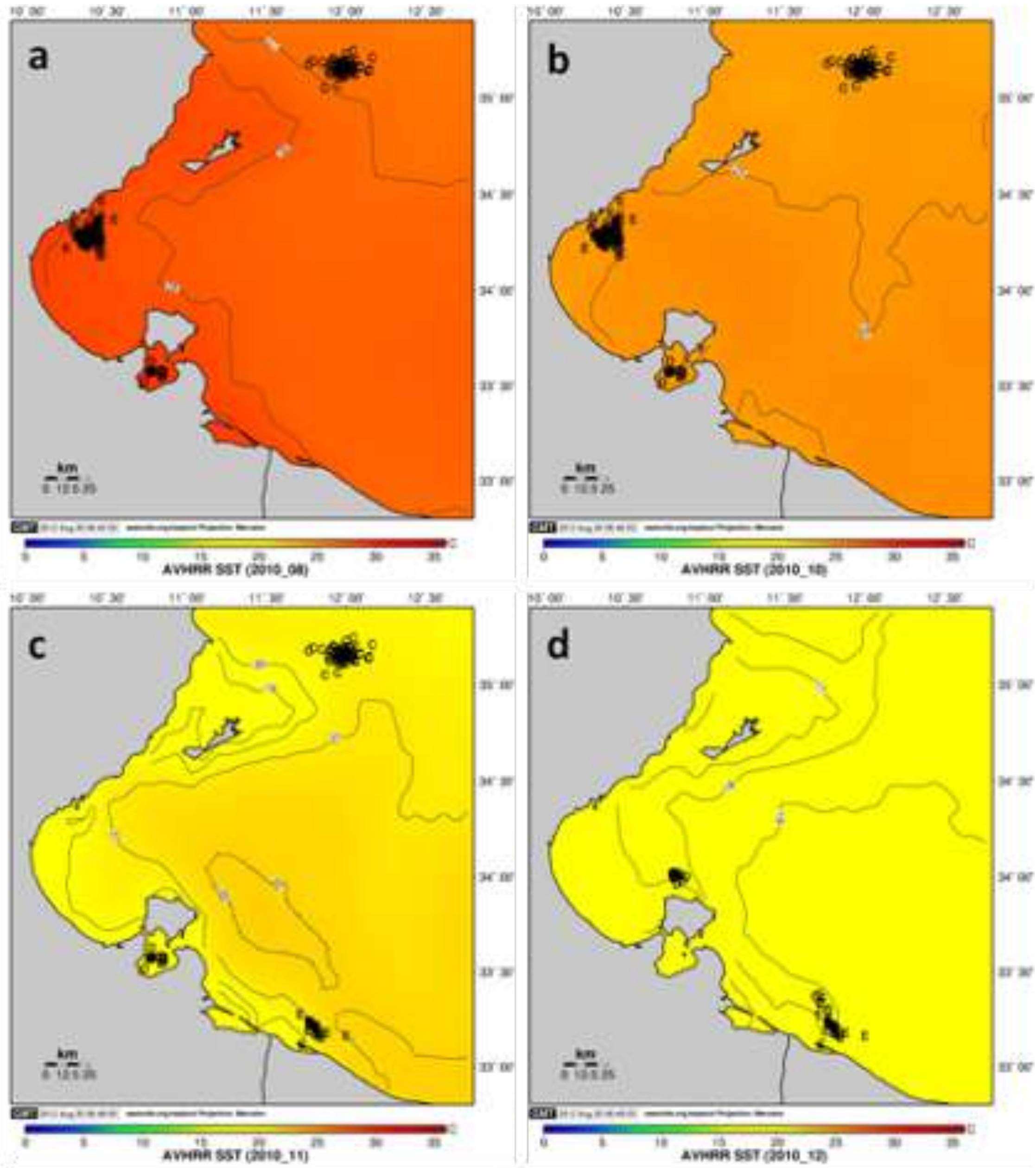


Figure 3.5. Frequency distribution of the prevalent bathymetry on the sites for which locations from the loggerhead turtles were received.



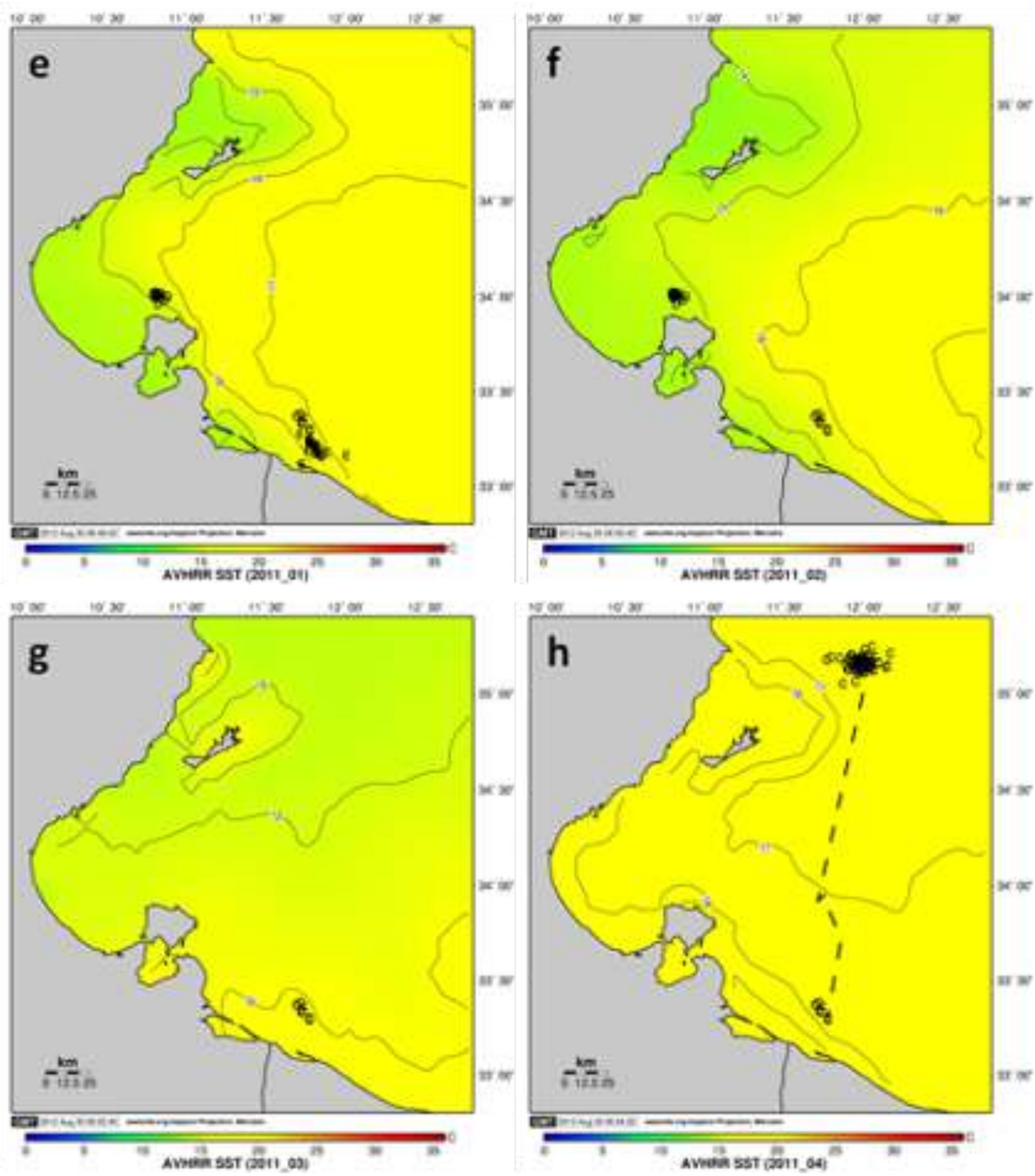


Figure 3.6. Monthly average sea surface temperatures during the tracking period 2010 – 2011:
a) August 2010, b) October 2010, c) November 2010, d) December 2010,
e) January 2011, f) February 2011, g) March 2011, h) April 2011.

Letters indicate residence sites of respective turtles; shown are 1 °C- contour lines. Panel h) indicates the return to the summer foraging area by turtle C (dashed line).

Chapter 4

Population structure and genetic diversity of loggerhead turtles nesting in Libya

By Sandra Hochscheid, Fulvio Maffucci, Almokhtar Saied and Abdulmaula Hamza

1. INTRODUCTION

Loggerhead turtles migrate long distances and exploit disparate, widely separated habitats at different times of their lives before returning to the natal region to reproduce (Bowen et al. 2004, Bowen & Karl 2007). In particular, females tend to remain faithful to their beach of origin (natal homing), which results in a considerable demographic autonomy for discrete nesting units at least over short ecological times (Avise 2000). Population growth rate depends mostly on local birth and death rates rather than on immigration or emigration from and to nearby nesting beaches. However, the precision of natal homing may vary significantly from very precise to hundreds of kilometres. Therefore, it is essential to identify these functionally independent units, called Management Units (MUs, Moritz 1994), to develop proper conservation strategies.

Surveys of the mitochondrial DNA (mtDNA) control region diversity has been widely exploited to identify MUs in loggerhead turtle populations. MtDNA is maternally inherited, and thereby, it allows to evaluate the genetic relationships among individuals in analogy to women's birth names in human populations. Nesting areas utilised by loggerhead turtle females belonging to the same MU will exhibit the same «matrilineal» surname, that is a comparable composition in terms of mtDNA control region sequence frequencies (Avise 1998). This unique mtDNA profile of MUs offers the opportunity to link feeding cohorts to their rookery of origin and to understand how threats on shared foraging grounds impact demographically independent MUs by using mixed stock analysis (MSA) methods (Bolker et al. 2007).

Located in the southern part of the Mediterranean Sea, Libya possesses more than 1000 km of sandy, a pristine coastline that is potentially suitable for loggerhead turtle nesting. The first available nest records are from the late 1970s and early 1980s (Armsby 1980, Schleich 1984). However, it was only in 1995 that the importance of this coast was recognised with substantial loggerhead turtle nesting discovered along different portions of the Libyan shores (Laurent et al. 1997, Magaritoulis et al. 2003).

In 2005, the Environment General Authority (EGA), supported by the Regional Activity Center for Specially Protected Areas (UNEPMAP-RAC/SPA), launched the Libyan Sea Turtle Program (LibSTP) to collect fundamental data on the Libyan loggerhead turtle population. Monitoring of nesting activity was organised by EGA Tripoli along approximately 34 % of the length of Libya's sandy beaches. Nesting was detected mainly in the Gulf of Sirte, the region around Benghazi, some sandy beaches of Aljabal Alakhdar (Cyrenaica) and the area of Derna-Tubrok (Hamza 2010). Around 800 nests yr−1 were counted, and although this number is probably still an underestimate of the real overall nesting effort in the country, it demonstrates the importance of the Libyan nesting rookery within the Mediterranean Sea (Hamza 2010). Understanding the level of genetic diversity of the Libyan population and its demographic independence from the adjoining Mediterranean rookeries is essential to develop proper conservation strategies and to ensure that management actions are directed at the appropriate scale within the Mediterranean region.

Therefore, in the framework of LibSTP, sampling for the genetic characterisation of Libyan loggerhead turtle nesting population was begun. In this chapter, we summarise the results of the analyses of mtDNA control region sequence diversity in adult females nesting in two distant areas within the Gulf of Sirte (a complete description of the work and discussion of the results can be found in Saied et al. (2012) and Clusa et al. (2013). The aims were to define the level of genetic differentiation and demographic autonomy of the Libyan nesting aggregation with respect to the other Mediterranean populations; to improve our understanding of the colonisation history of the Mediterranean Sea and to investigate the spatial distribution of Libyan individuals among different developmental and foraging grounds.

2. MATERIALS AND METHODS

A complete description of the methods employed can be found in Saied et al. (2012), and Clusa et al. (2013). In synthesis, samples for genetic analysis were collected during nest excavations conducted by biologists of LibSTP as part of the ongoing monitoring project of the loggerhead turtle nesting activity in Libya (see reference within this report). A small quantity of muscle or skin tissues were taken from dead hatchlings and stored in 95 % ethanol. To reduce the risk of pseudo-replication only nests that were laid within fifteen days were sampled.

Two sampling campaigns were conducted. Twenty-seven samples were collected and shipped to the Department of Animal Biology and IRBio, Faculty of Biology, the University of Barcelona for the analysis. Additional forty-nine additional nests were sampled during the 2009 nesting season at two sites in the Gulf of Sirte (Misurata, N = 14 and Sirte, N = 35) (Figure 4.1) and sent to the Stazione Zoologica Anton Dohrn of Naples for analysis.

An 815 base pairs fragment of mitochondrial DNA was amplified by polymerase chain reaction (PCR) using mtDNA control region primers designed by Abreu-Grobois et al. (2006). This fragment completely encompasses the shorter (380 bp) region, which was used in previous studies.

Mitochondrial haplotypes were classified according to the online haplotype registry that is maintained by the Archie Carr Center for Sea Turtle Research (ACCSTR, http://accstr.ufl.edu/ccmtdna.html). Genetic differentiation between the two Libyan nesting beaches and among these and the other Mediterranean nesting populations for which genetic data were available was verified (Saied et al. 2012, Clusa et al. 2013).

The new information generated by this study was employed to reanalyse previously published data from loggerhead turtle developmental grounds in the Mediterranean Sea and the Atlantic Ocean using a Bayesian mixed stock analysis based on the many-to-many approach (Bolker et al. 2007). The complete dataset utilised in this analysis can be found in Saied et al. (2012).

3. RESULTS AND DISCUSSION

Six different mtDNA haplotypes were identified in the Libyan samples (Table 4.1). Both datasets agreed in identifying Libya as the most genetically diverse nesting area in the Mediterranean (Saied et al. 2012, Clusa et al. 2013, Table 4.2). This is because of the presence of three unique haplotypes (CC-A26.1, CC-A65.1 and CC-A68.1, Table 1).

Analysis of the long mtDNA sequence made it possible to show genetic differences of the two relatively close nesting areas in Libya, which was not detected by the conventional short sequence (Saied et al. 2012). This was due to the splitting of the common haplotype CC-A2 into two sub-haplotypes, CC-A2.1 and CC-A2.9. The former is the most frequent long subtype reported in the Atlantic loggerhead turtle nesting stock and also the only one described in Calabria (Garofalo et al. 2009, Monzon-Arguello et al. 2010, Nielsen 2010). The origin of CC-A2.9 was not known, but it was recently found in juvenile and adult loggerhead turtles from the North Adriatic Sea and the Gulf of Gabés, which are two of the most important neritic foraging grounds for Mediterranean loggerhead turtles (Garofalo 2010, Karaa et al. 2016). This finding, along with the absence of this haplotype in the Atlantic loggerhead turtle stock, suggests that CC-A2.9 evolved in the Mediterranean Sea from the shared subtype CC-A2.1.

Apart from CC-A2.1 and CC-A2.9, four other long haplotypes were found (Table 1). One, CC-A26.1, included the short sequence CC-A26, that had been previously reported from several Mediterranean foraging habitats but whose rookery of origin was still unknown (Laurent et al. 1998, Carreras et al. 2006, Maffucci et al. 2006, Casale et al. 2008). This haplotype originated from a single mutation from the variant CC-A2.9, which strongly indicated a local origin.

The Libyan nesting rookery was genetically differentiated from all the other Mediterranean nesting populations (Clusa et al. 2013, Figure 4.2). Both the relatively high molecular diversity and results from the genetic differentiation tests make a strong case that Libya hosts an important Management Unit and plays a crucial role for the conservation of the Mediterranean loggerhead turtle population as a whole. Moreover, the significant difference in haplotype frequencies between Misurata and Sirte, detected by analysing the longer mtDNA fragment, suggests the possible existence of more functionally independent Management Units along the Libyan coasts. These sampling locations are separated by only a few hundred kilometres which imply that fine-scale homing behaviour may be present in loggerhead turtle females nesting in Libya meaning that they can return exactly to their natal beach to reproduce (Bowen et al. 2007). The genetic distinctiveness of the two areas must be taken into consideration to avoid modifying the genetic structure of the Libyan population through management activities.

Regarding the species history within the Mediterranean Sea, Clusa et al. (2013) suggested that the presence of four mutations in a Libyan haplotype (CC A65.1) from its Atlantic ancestor haplotype (likely to be CC-A2.1) places the oldest colonisation of the Mediterranean as a pre-Holocenic event occurring ca. 65,000 years ago (20,000–200,000). Thus, the loggerhead turtle may have survived the last glacial period (~18,000 years ago) by nesting at least in some warm refugia along the Libyan coasts where it suffered mild or null bottlenecks (Clusa et al. 2013).

The mixed stock analysis suggested that juveniles from Libya remain preferentially in the Eastern Mediterranean basin during the oceanic developmental phases, while at the time of the transition to the neritic stage they select foraging grounds closer to their natal beach such as southern Tunisia (Figure 4.3). These results are coherent with a scenario in which surface circulation influences the dispersal pattern of loggerhead turtles from Libya during the early phase of development and also plays a relevant role for the selection of foraging sites at a later stage in combination with the juvenile natal philopatry (Bowen et al. 2004).

The new information provided by this study fills an important gap in our knowledge of the loggerhead turtle population structure in the Mediterranean Sea, demonstrating that Libya hosts an important and unique loggerhead turtle management unit. The protection of this assemblage is fundamental for the conservation of the Mediterranean stock as a whole.

It is of the extreme importance to continue and reinforce the monitoring of Libyan coasts to protect this population and to complete the genetic survey of the regions where loggerhead turtle nesting occurs.

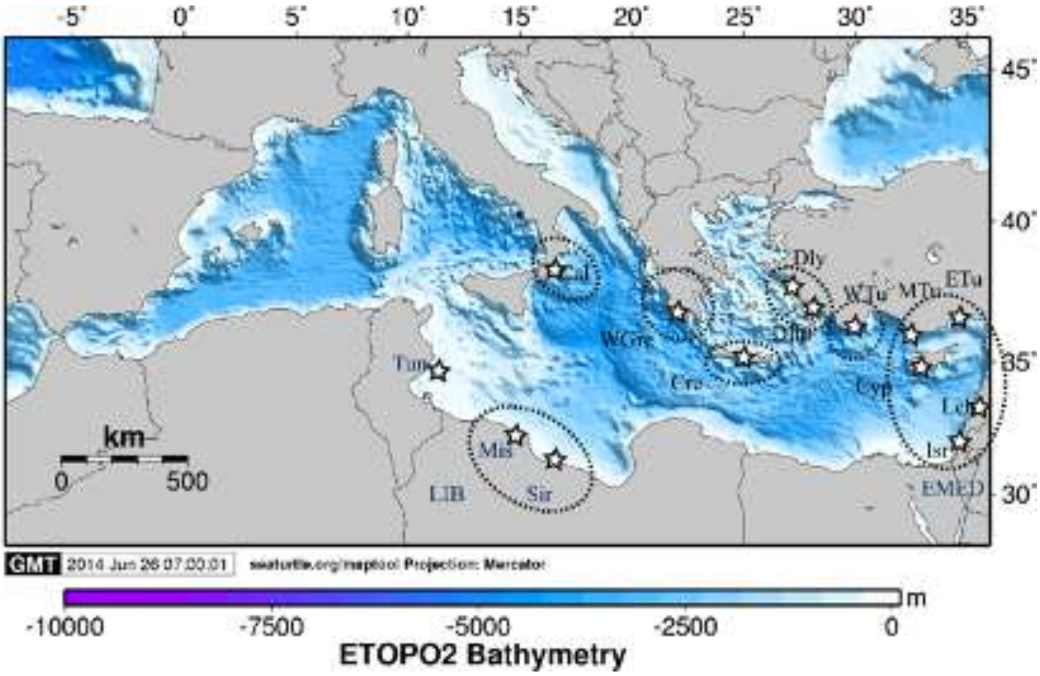


Figure 3.5. Frequency distribution of the prevalent bathymetry on the sites for which locations from the loggerhead turtles were received.

Nesting areas: Tunisia (Tun), Libya (LIB which includes Misurata (Mis) and Sirte (Sir)), Eastern Mediterranean (EMED which includes Israel (Isr), Lebanon (Leb), Cyprus (Cyp), Eastern Turkey (ETu) and middle Turkey (MTu)), Western Turkey (WTu), Dalaman (Dlm), Dalyan (Dly), Crete (Cre), Western Greece (WGre), Calabria (Cal).
Dashed circles indicate proposed management unit divisions for recognition of demographically isolated nesting populations,.

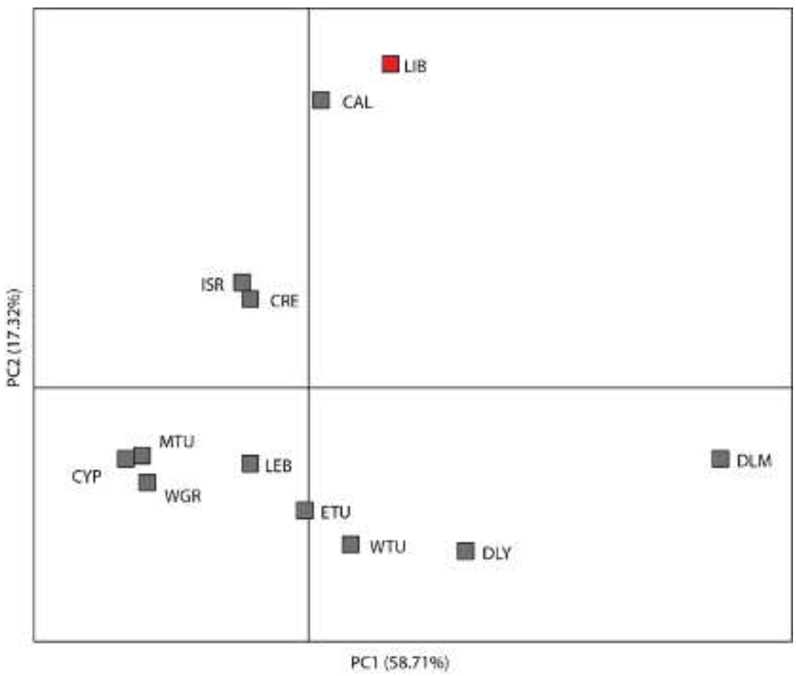


Figure 4.2. Principal Coordinate Analysis for pairwise genetic distances (γst) between nesting colonies in the Mediterranean (Modified from Clusa et al. 2013).

First two Principal Coordinates (PC1 and PC2) and the percentage of variation explained by the two axes included.

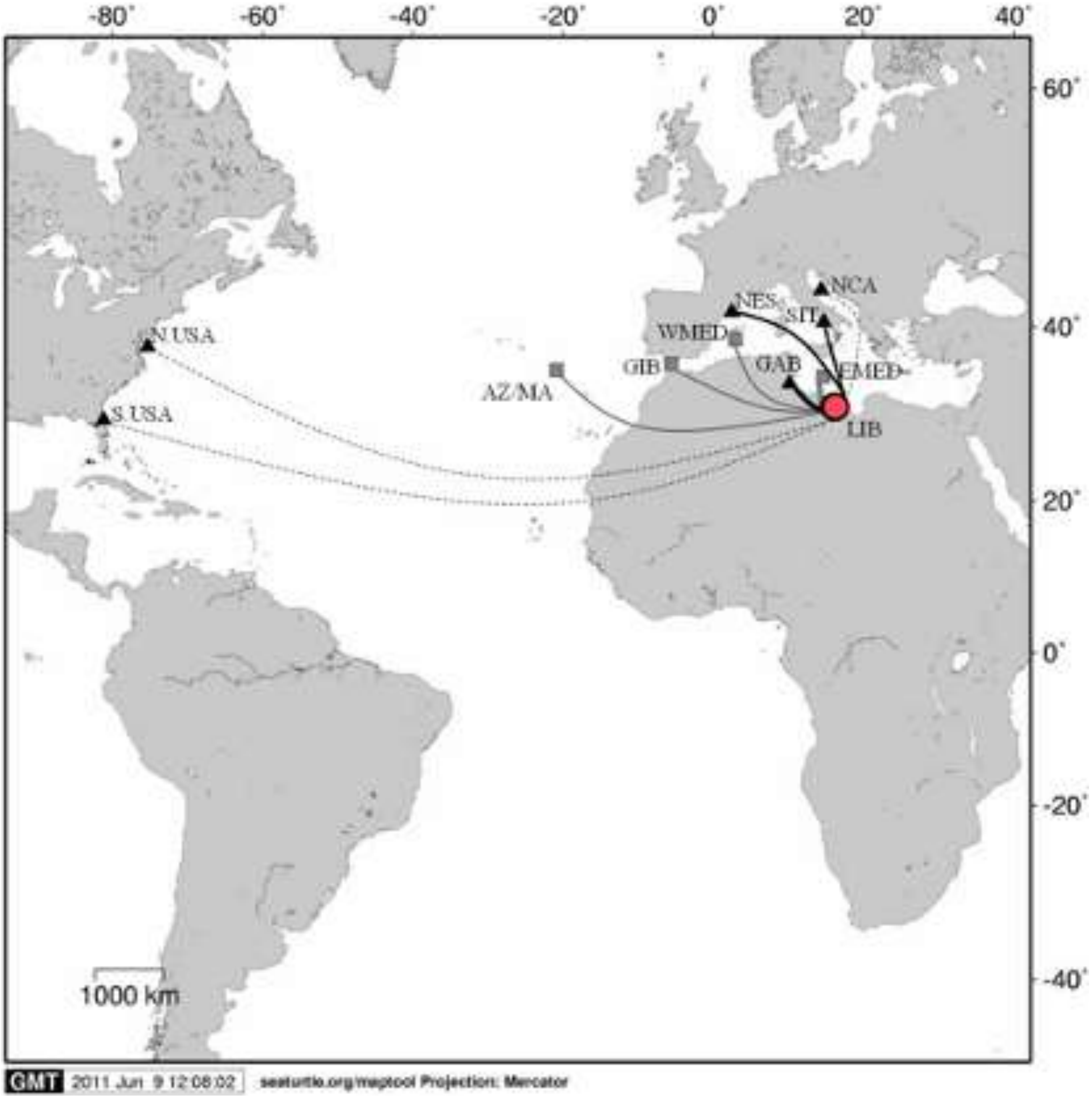


Figure 4.3. Dispersal pattern of loggerhead turtles from Libya as inferred by rookery-centric analysis: line thickness is proportional to the fraction of turtles going from Libya to each oceanic (square) and neritic (triangle) foraging grounds (Modified from Saied et al. 2012).

Dotted lines show pathways representing less than 10 % of the intake of a given foraging ground. Grey circles represent the source populations used in the two mixed-stock analyses (LIB: Libya; CAL: Calabria; GRE: Greece; M.ISL: Mediterranean Islands comprising Cyprus and Crete; TUR: Turkey; ISR: Israel; CV: Cape Verde; BR1: Rio de Janeiro/ Espírito Santo; BR2: Bahia/Sergippe; DT: Dry Tortugas; YUC: Quintana Roo, Yucatan; NWFL: Florida coast/northern Gulf of Mexico; NEF-NC: northeast Florida to North Carolina; SFL: South Florida; NES: northeastern Spain; SIT: southern Italy; NCA: north central Adriatic; ST: southern Tunisia; S./N. USA: southern/northern US Atlantic coast; AZ.MA: Azores and Maderia; GIB: Strait of Gibraltar; W/EMED: western/eastern Mediterranean).

Table 4.1. Loggerhead mtDNA haplotype frequencies in the Atlantic
and Mediterranean nesting populations used as baseline in the mixed stock analysis.

Nesting populations														
Mediterranean rookeries														
	LIB													
Long Hapl.	**MIS**	**SIRa**	**SIRb**	**CAL**	**WGR**	**CRE**	**CYP**	**LEB**	**ISR**	**DLY**	**DLM**	**WTU**	**MTU**	**ETU**
CC-A2.1	12	16	11	22	34	16	44	17	15	25	5	60	46	60
CC-A2.8						4								
CC-A2.9	1	12	10						2					
CC-A3.1	1	2	3					2		15	15	16		8
CC-A6.1					3									
CC-A13.1													1	
CC-A20.1				14										
CC-A26.1		4	1											
CC-A29.1									2					
CC-A31.1				2										
CC-A32.1					1									
CC-A43.1														1
CC-A50.1							1							
CC-A52.1														1
CC-A53.1													1	1
CC-A65.1			2											
CC-A68.1		1												
Total	14	35		38	38	20	45	19	19	40	20	76	48	72
Pop size	841	15	2062	418	572	60	57	194	91	537	652	575		
Source	A	B	C	B	B	B	B	B	D	D	D	D	D	

Libya (LIB), Calabria (CAL), western Greece (WGR), Crete (CRE), Cyprus (CYP), Lebanon (LEB), Israel (ISR), Dalyan (DLY), Dalaman (DLM), western Turkey (WTU), middle Turkey (MTU), eastern Turkey (ETU). Sources: (A) Saied et al. (2012), (B) Clusa et al (2013), (C) Garofalo et al. (2009), (D) Yilmaz et al. (2011).

Table 4.2. Haplotype and nucleotide diversities, including standard deviations (±). Population abbreviations as in Table 4.1.

	Haplotype diversity	Nucleotide diversity	Source
SIRT	0.668 ± 0.037	0.0011 ± 0.0008	Saied et al 2012
MIS	0.275± 0.148	0.0005 ± 0.0005	Saied et al 2012
LIB	0.704±0.054	0.0017±0.0012	Clusa et al. 2013
ISR	0.374±0.130	0.0005±0.0005	Clusa et al. 2014
LEB	0.199±0.112	0.0002±0.0004	Clusa et al. 2015
CYP	0.044±0.042	0.0001±0.0002	Clusa et al. 2016
ETU	0.297±0.067	0.0004±0.0005	Clusa et al. 2017
MTU	0.082±0.054	0.0001±0.0002	Clusa et al. 2018
WTU	0.337±0.054	0.0004±0.0005	Clusa et al. 2019
DLM	0.395±0.101	0.0005±0.005	Clusa et al. 2020
DLY	0.481±0.042	0.0006±0.0006	Clusa et al. 2021
CRE	0.337±0.110	0.0004±0.0005	Clusa et al. 2022
WGR	0.198±0.083	0.0003±0.0004	Clusa et al. 2023
CAL	0.541±0.049	0.0007±0.0007	Clusa et al. 2024

Chapter 5

Public Awareness and outreach activities of LibSTP

By Salih Diryaq & Abdulmaula Hamza

1. INTRODUCTION

All seven sea turtle species are on the Red List of Endangered Species (IUCN 2014). The Loggerhead turtle *Caretta caretta* is the only species to date found to nest along Libyan sandy beaches, which is considered one of the most important nesting beaches of this Mediterranean Sea species. Nesting activity of the Loggerhead sea turtle is spread along the Gulf of Sirte (including beaches east of Misurata), beaches of the Aljabal Alakhdar(Cyrenaica), and the Ain Al-Ghazala beach in Tobruk, in addition to some nesting activity at Farwa island at the northwest of Libya.

The most critical threats to sea turtles are by-catch in fisheries, marine pollution including oil and plastic pollution, illegal fishing such as dynamite fishing, tourist development, destruction of beaches, nest tampering, egg collection, and trade. However, despite the existence of laws and regulations to protect endangered organisms, including sea turtles, applying these regulations in some regions of the world, such as Libya, is still in need of enforcement.

These threats impact the sea turtle community, requiring further efforts by involving local populations, fishers, and stakeholders. Partnerships with these stakeholders can provide valuable lessons for enhancing the protection of sea turtles and their habitats by involving the communities in Conservation, especially since one of the main objectives of the Libyan Seaturtle Program is to create partnerships with the local community and stakeholders, for their contribution to Conservation, for example, reducing egg collection and nesting on beaches.

Raising environmental awareness is a critical tool to preserve species, as it widens the environmental knowledge and enhances positive actions to protect the environment and preserve natural resources (Ehrhardt & Witham, 1992). The best way to launch an education program is possibly combining written documents, audio-visual presentations, and face-to-face interaction (Clark, 1991).

Since its inception in 2005, the LibSTP has been keen to promote sea turtle awareness programs alongside surveillance and conservation programs.

Over the past years, various awareness methods have been used, including non-traditional methods in more attractive and fun ways. Efforts have been made to reach diverse society segments through multimedia, presentations, and live field activities.

The present chapter showcases the methods and means of awareness that have been used during the past fifteen years of awareness and outreach work along with research, monitoring, and Conservation.

1.1. Workshops and presentations

Organising workshops, seminars, and presentations are one of the awareness methods aimed primarily at enhancing knowledge of ecosystems in general, particularly sea turtles and their habitats, and threats to them in their feeding, breeding, and nesting habitats better conservation and reducing threats. Many workshops and presentations have been organised that have contributed to raising awareness and knowledge directly or indirectly. Here is a selection of the most important activities related to this:

- In November 2007, an Expert meeting on regional conservation priorities in the Mediterranean was organised by LibSTP and the Centre for Regional Activities for Specially Protected Areas. Experts from Tunisia, Turkey, Greece, Italy, Spain, Cyprus, and Libya met to prepare these priorities. This meeting of the ad hoc group of Mediterranean experts was nominated in consultation with the Contracting Parties and relevant partner organisations to draft the updated version of the Mediterranean Action Plan. This meeting was the local and national media event and showed the importance of turtles to the marine ecosystem and Libya's importance to these endangered species in the Mediterranean.

- In April 2010, with SPA/RAC participation, The LibSTP organised the second national workshop at the Environment General Authority Headquarters in Tripoli. Mr. Aterf Ouerghi introduced several presentations on the regional Action Plan of SPA/RAC. All LibSTP teams also presented their progress of beach monitoring, stranding, tagging, and awareness activities conducted in the 2009 season. About fifty participants from EGA, Universities, and NGOs attended the workshop.

- In July 2010, the LibSTP organised an awareness day at the University of Sirte. Several faculty members and students attended the event, during which researchers from LibSTP and SPA / RAC gave presentations on the importance of sea turtles to the marine environment and the program's efforts to preserve these species and their habitats in Libya.
- In May 2018, the LibSTP organised a workshop in Tripoli. Several presentations by researchers of the Libyan Turtle Protection Program on the results of fieldwork for the 2017 season and some academic papers on sea turtle biology and Conservation in Libya.

- After the end of the 2018 season, LibSTP organised an awareness day at Al-Ilmu Darajat Primary School in Sirte, attended by about 250 students, who were divided into five groups to accommodate them in the exhibition hall, during which they gave a simplified lecture about the importance of sea turtles and the threats to them and our role in reducing and protecting threats.

The program became a founding member of the North African Sea turtle Network since its inception in July 2019 in Tunisia. Several researchers from LibSTP take part in the workshop, and Mr. Almokhtar Saied presented the current status of sea turtle conservation in Libya.

On December 16th 2020, The LibSTP collaborated with SPA/RAC and organised the third national Sea turtle workshop. This workshop was held online due to the Covid-19 pandemic situation. The workshop mainly focused on introducing the revised and updated version of the National Action Plan for Sea turtles and their habitats. This revised action plan will be a plan for the next five years of research and conservation work of the LibSTP and its NGOs partners in Libya. The Action Plan presented, and the expert in charge received several comments from the audience, which the expert will use in finalising the text and consider it adopted. Participants from all Libyan coastal cities, representing Universities, Research Institutes, NGOs, and LibSTP teams, attended the workshop. The workshop was also live-streamed on LibSTP Facebook page, and several hundred fans followed it online. It was another opportunity for outreach and awareness on Sea turtle conservation work in Libya and the Mediterranean.

1.2. LibSTP in Media

The traditional media tools are in the past, the newspapers, the radio, and the television. Nowadays, media expanded to include internet websites, blogs, and social media platforms. Modern media takes up a large part of our daily lives and has a clear impact on societies' individual and collective actions as a whole. Social media plays a prominent role in interpreting and understanding things and the world around us in general. The media is one of the most significant contributors to promoting society's culture and awareness, and it is essential to know how to exploit its impact positively and beneficial to the whole world, particularly ecosystems and natural resources. The LibSTP launched its Facebook pages on August 6th 2017, and today it is followed by more than 5242 followers. Visit & join us at https://www.facebook.com/LibSTP

In addition to Facebook, several media contributions for awareness activities about sea turtles are:

- Since its establishment, LibSTP, A weekly TV reportage, and several interviews by the national TV broadcasting from Sirte each Thursday to provide information on the program and its activities.
- The former coordinator of the program, Dr. Hamza, appeared live on Al Jazeera TV to discuss the Libyan coast's importance to the Mediterranean populations of sea turtle nesting, feeding, and as a wintering area.
- Several Libyan Tv stations followed the progress of LibSTP works. Examples of such coverage can be accessed through these links (https://www.youtube.com/watch?v=Zg1p75M4QkA, https://www.youtube.com/watch?v=yPVL10hHDzs, https://www.youtube.com/watch?v=Gifly81Fl9w).

Additionally, several Libyan websites (newspapers and TVs) featured news on LibSTP at their news coverage; examples include 218TV, WTV, Libya24, LANA1, LANA2, CNA, PANAPRESS, AfricaGateNews, Libyakhbar.

Dedicating a segment from the program «Towards a Better Environment» by the local Sirte Radio, prepared by Mr. Salih Diryaq, talked about the sea turtle's importance and threats. The program was broadcast over the years 2009 and 2010, and it was broadcast repeatedly in 2019.

Hosting LibSTP researchers at the morning program of Radio Sirte Cultural office in Sirte, for three consecutive days during the 2019 season.

A full page of the local newspaper Al-Qaradabiya in Sirte, a bi-monthly newspaper, covers LibSTP activities and raises awareness about the importance of sea turtles during the nesting season in 2006-2007

الاحد 6 من شهر صفر الموافق 1 من شهر النوار 1377 و.ر

مدير فرع هيئة البيئة بسرت :

لهذا السبب أقيمت محمية خليج سرت للسلاحف

البيئة السليمة الخالية من كافة الملوثات تعد هي الوعاء التام لصحة الانسان ومصدر إمداده في كافة المجالات الحياة الاجتماعية والاقتصادية والعلمية والثقافية . ولكن ما أن تلوثت البيئة المحيطة بنا لأصبحت مصدر إزعاج وخطر لتهدد صحة الانسان ولمعرفة العديد من التفاصيل حول فرع الهيئة للبيئة بشعبية سرت التقينا بالمهندس صالح محمد درياق مدير فرع البيئة .

1.3. Documentaries and short videos

Videos and short documentaries are useful tools to deliver the conservation message. Furthermore, video making equipment is relatively cheap and easy to use (Hudson, 1988). Therefore the LibSTP utilised the audio-visual media since its inception in 2005, more than one video was produced to increase outreach and awareness activities of the program:

- Several short videos on the LibSTP works were produced in 2005. A short video was produced in the 2005 season (https://vimeo.com/39760098) and 2006 season (https://vimeo.com/39760097).

Other videos also include these: https://www.youtube.com/watch?v=RxpaRZoRra4&feature=youtu.be, https://www.youtube.com/watch?v=HM4RiKa0o8w&feature=youtu.be, https://www.youtube.com/watch?v=apzHMCvCmOM, https://vimeo.com/31430192, https://vimeo.com/31432172.

Also, several NGOs in Libya are increasingly producing media materials on bycatch (https://www.youtube.com/watch?v=RujDr1dTeNI, https://www.youtube.com/watch?t=242&v=jQzPYH7o3R0&feature=youtu.be, https://www.youtube.com/watch?v=wfX_97IIZGs)

In 2015, during the 23rd International Seaturtle Symposium, held in Turkey, Over 120 paintings and artworks made by Sirte primary school students were on display in the conference venue's main hall. Selected paintings were later donated to the symposium's silent auction, and some three paintings were sold in the auction, and some were presented to some prominent Mediterranean experts who helped the program personnel training, namely Dr. Flegra Bentivegna (Italy) and Mr. Andreas Demetropoulis (Cyprus). The obtained amount from selling two paintings was later used to present gifts to the local school children at these schools.

During the same event, The LibSTP presented a short video on this activity's process, under the name «A message of hope». The video was well-received by the sea turtle scientific community of the symposium.

The 2010 study of field sampling for sex ratio (chapter 3) also appeared in a short documentary video (https://vimeo.com/31491131).

1.4. Field activities

What distinguishes field activities is that they make partners integrate with the team and feel part of it, leading to their acquisition of a love of nature and resources, which stimulates their responsibility towards nature and promotes positive feedback from Conservation. Here are some of the field outreach activities that the program teams had organised:

- In 2005, at the beginning of the program, we had excellent cooperation with the Libyan Scout movement in Sirte, who helped monitor the beach and conduct awareness activities in the city.

At the end of the nesting season in 2006, a photographic exhibition on field survey activities and the monitoring, Conservation, and sea turtle tagging was held at 30th Beach west of Sirte, attended by residents of the village, the exhibition explained the importance of preserving sea turtle nests and avoiding their destruction or tampering.

In 2010, during the release of several loggerhead turtles from Misratah, for tracking study, the event was attended by school children, scouts, local fishers, and the public media (https://www.youtube.com/watch?v=psZDKonL9Lw).

- In 2017, during the hatching season, the Libyan Scouts of Sirte and the LibSTP team participated in the field survey of Al-Gbeba Beach and the follow-up and documentation of the hatching nests.



1.5. Other outreach and awareness activities

Traditional outreach methods based on lectures or posters are usually boring, and maybe counterproductive, as awareness may also be a double-edged tool in recent years. More attractive and fun methods evolved to instigate interactive participation while reaching as many public members as possible. For example, when we organised activities with school students, spread images and videos on social media pages, and news reports broadcasted by Libyan radio and TV channels, this has led to more requests received by LibSTP from several schools to participate in such activities. Here are the non-traditional outreach activities organised:

- In 2015, a workshop for the children of eight primary schools in Sirte was organised over two days, during which preparations for the workshop lasted two months, in coordination with the School Activity Department of the Ministry of Education. With their teachers, we selected some talented children in four activity areas: drawing, stereoscopic industry, acting, oratory, and speech.

During the workshop held in late January 2015, the children produced:

- About 120 paintings using different types of colors and drawing materials.
- About 20 artworks show sea turtle and their habitats using recycled materials collected from beaches such as plastic, cardboard, snails, and small sea stones.
- A play that embodied dialogue between figures from the marine environment such as the sea turtle and the dolphin, including the human being who

represents evil in the play as the main polluter of the marine environment.

- Children from the group of oratory and delivering video messages addressed to the world from the children of Libya in the form of a short film entitled «A Message of Hope».

Later, these works of art were displayed in the main hall of the 23rd International Symposium of Sea Turtles, held in Turkey; some of these paintings were donated later to the silent auction of the symposium, and about three paintings were sold at auction. The amount subsequently obtained was used to give gifts to local school children in these schools.

- by the end of the 2017 nesting season, LibSTP organised a seaside awareness event with about 40 children under the age of seven from Sirte.
  - Cleaning the seaside from plastic waste left by holidaymakers on the beach with students' attention that plastic is one of the most dangerous wastes that harm marine organisms, including sea turtles.
  - To draw students' attention and minds to sea turtles through the two models made in sea turtles is one of the endangered organisms and the impact of plastic waste on them.
  - It was a fun day for both children and adults from Sirte, helped to heal some of the stress caused by the armed conflict in the country.

The activity also included a visit to one of the hatched nests to watch young turtles come out of the nest and make their way to the sea with a simple explanation of the importance of sea turtles and their role in marine ecosystems.




During the 2018 season, an awareness event was organised in partnership with the Sirte Culture Office for The Sirte Peace Center children for people with special needs and their families. The program included drawing a large sea turtle model using plastic residues dumped on the beach as a warning message of the danger of plastic scares on ecosystems and sea turtles. The activity aimed at three aspects, the environmental aspect, awareness, and humanity:

- Environmental: Community involvement in the clean-up of plastic waste dumped on the seashore, which everyone knows has many adverse effects on marine organisms.
- Awareness: Educating and educating the local community and drawing their attention to marine organisms, especially sea turtles, and the impact of plastic waste on them.
- Human: An entertainment activity for children with special needs to motivate their integration into society and share their activities with others.

The event was covered by several media outlets, among them the following pages: https://hunalibya.com/local-affairs/6817/.


The aerial image of the turtle model and around it children and their families had a prominent role in educating the local community after it was widely circulated on social media platforms in Libya, and it was also shared by a number of activists at the regional and international level, as it was placed as a cover image in the tenth edition of the Journal of Sea Turtles in Africa For the year 2018.

The program will continue using all available means to increase awareness about the sea turtles and the Libyan coastline's role in nesting, feeding, and wintering of several groups of sea turtle species to benefit the whole Mediterranean biodiversity conservation.


AFRICAN SEA TURTLE NEWSLETTER

The Libyan Sea Turtle Program created this turtle from plastic collected from the beach to raise awareness about the seriousness of plastics in the marine environment.

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Recommendations

This book was a result of more than a decade of dedicated work in studying and conservation of marine turtles in Libya. The hard work of all field and lab teams in Libya and abroad was the result of a noble well to protect these endangered species and to know more on the various aspects of turtle nesting biology, sex ratio and the impact of increased incubation temperature, tracking those turtles after completion of nesting season, and know more on their distributions and finally to understand the genetic make-up of loggerhead marine turtles in Libya, and how its related to other rockeries in the Mediterranean.

All of the above efforts yielded various important results, and opened the research horizon for more questions to be answered in future. The big Mediterranean question on how many nests Libya have each year, is still not fully answered, though this work present some valuable data in order to calculate such a number in the future.

The collaboration with SPA/RAC and its partners in the Mediterranean, was an example of fruitful Mediterranean collaboration, including south-south collaboration with Tunisia. Libya was the focus of several international organisations and research institutes, therefore, our collaboration through SPA/RAC started as early as the first phase of discovering turtle nesting activity in Libya, during 1995, when the centre was just established. In that collaboration, WWF and MEDASSET was also involved in the mission of 1995. SPA/RAC also supported the second and third phases of the national survey in 1996 and 1998 respectively. Later in early 2000 onwards, SPA/RAC also supported the participation of several Libyan researchers to Lara training sessions on nesting monitoring in Cyprus, which enables us to start our monitoring program for nesting (Chapter 1). In 2008 onwards, collaboration expanded to include the Stazione Zoologica in Naples, who supported LibSTP in training on turtle rescue techniques. Tracking and genetic studies (Chapter 3, 4). Collaboration with Sfax university in Tunisia, resulted in the first assessment of sex ration in loggerhead turtle hatchlings from Libya (Chapter 2)

Inline with the issue of this work, another work was revised and updated, the national Action Plan for conservation of marine turtles and their habitats. A first edition was issued before the establishment of LibSTP in 2003, and the new version built on the excellent results of this program along the past 15 years, and taken in consideration scientific developments in this field. A full text of the revised action plan can be found at SPA/RAC website.

The following are some recommendations for the future directions of the LibSTP:

1. Strengthen the legal framework of marine protected areas, by issuing the proposed law that was drafted in 2014, by the House of representatives.
2. Continue monitoring of known nesting beaches, and expand the monitoring coverage to some less known areas, such as the Gulf of Sirte beaches, to the east of Sirte and west of Zouitina. Areas to the east of Tobruk and to the northwest of Benghazi are also a priority.
3. Maintain the effort of monitoring at the main beaches along the coast, for the full season to keep data on annual fluctuations of nests, and forecast national level nesting data in future.
4. Continue the sex ratio monitoring, genetic studies and tracking studies, by extending them to other areas to the east of the country.
5. Establishment of LibSTP partnership program for Libyan NGOs, to become LibSTP partners at their localities and help to implement the activities.
6. Establish a national project on assessment and minimisation of interactions between marine turtles and fisheries in the Libyan waters.
7. Establish first Aid centres and rescue centres in the nesting area between Tripoli and Tobruq.
8. Setup a national strategy or plan to increase awareness efforts to specific stakeholders (fishers, schools, decision makers on national and local levels).

References cited

1. Abreu-Grobois A, Horrocks J, Formia A, Dutton DL, LeRoux R, Vélez Zuazo J, Soares LS, Meylan A (2006) New mtDNA D-loop primers which work for a variety of marine turtle species may increase the resolution of mixed stock analysis. In: Frick M, Panagopoulous A, Rees A, William K (eds) 26th annual symposium on sea turtle biology and conservation. International Sea Turtle Society, Athens, Greece
2. Armsby JK (1980) Kouf National Park marine survey final report: April–July, 1980. Arab Centre for the Study of Arid Zones and Dry Lands. *Unpublished Report*.
3. Avise, J.C. (2000) Phylogeography: the history and formation of species, Vol. Harvard University Press, Cambridge, Massachusetts, London, England
4. Avise, J.C. (1998). Conservation genetics in the marine realm. *Journal of Heredity*, 89(5), 377-382.
5. Benabdi, M., & Belmahi, A. E. (2020). First record of loggerhead turtle (*Caretta caretta*) nesting in the Algerian coast (southwestern Mediterranean). *Journal of the Black Sea/Mediterranean Environmen*t, 26(1): 100-105.
6. Bentivegna F, Hamza A, Saied A, Elghmati H, Elsharif E, Hays GC, Hochscheid S (2008) Movements of juvenile loggerhead turtles accidentally caught by fishermen in the Libyan Sea. *Third Mediterranean Conference on Marine Turtles, Hammamet, Tunisia.*
7. Bentivegna, F. (2002). Intra-Mediterranean migrations of loggerhead sea turtles (*Caretta caretta*) monitored by satellite telemetry. *Marine Biology*, 141(4), 795-800.
8. Bolker, B. M., Okuyama, T., Bjorndal, K. A., & Bolten, A. B. (2007). Incorporating multiple mixed stocks in mixed stock analysis:'many-to-many'analyses. *Molecular Ecology*, 16(4), 685-695.
9. Bowen, B. W., & Karl, S. A. (2007). Population genetics and phylogeography of sea turtles. *Molecular Ecology*, 16(23), 4886-4907.
10. Bowen, B.W., Bass, A.L., CHOW, S.M., Bostrom, M., Bjorndal, K.A., Bolten, A.B., Okuyama, T., Bolker, B.M., Epperly, S., Lacasella, E. and Shaver, D. (2004). Natal homing in juvenile loggerhead turtles (*Caretta caretta*). *Molecular Ecology*, 13(12), 3797-3808.
11. Bradai MN, Bentivegna F, Jribi I, El Quaer A, Maatoug K & A., El Abed (2009) Monitoring of a loggerhead sea turtle, *Caretta caretta*, in the Central Mediterranean via satellite telemetry. In: Demetropoulos A, Turkozan O (eds) *The Second Mediterranean Conference on Marine Turtles. Barcelona Convention - Bern Convention - Bonn Convention (CMS), Kemer, Turkey*
12. Broderick AC, Coyne MS, Fuller WJ, Glen F, Godley BJ (2007) Fidelity and over-wintering of sea turtles. *Proceedings of the Royal Society* B 274 1533-1538
13. Broderick, A. C., & Godley, B. J. (1996). Population and nesting ecology of the green turtle, *Chelonia mydas*, and the loggerhead turtle, *Caretta caretta*, in northern Cyprus. *Zoology in the Middle East*, 13(1), 27-46.
14. Camiñas, J.A.; Kaska, Y.; Hochscheid, S.; Casale P.; Panagopoulou, A.; Báez, J.C.; Otero, M. M.; Numa, C., Alcázar, E. 2020. Conservation of marine turtles in the Mediterranean sea [brochure]. IUCN, Malaga, Spain.
15. Carreras, C., Pont, S., Maffucci, F., Pascual, M., Barcelo, A., Bentivegna, F., Cardona, L., Alegre, F., SanFelix, M., Fernandez, G. and Aguilar, A. (2006). Genetic structuring of immature loggerhead sea turtles (*Caretta caretta*) in the Mediterranean Sea reflects water circulation patterns. *Marine Biology*, 149(5), 1269-1279.
16. Casale P, Broderick AC, Caminas JA, Cardona L, Carreras C, Demetropoulos A, Fuller WJ, Godley BJ, Hochscheid S, Kaska Y, Lazar B, Margaritoulis D, Panagopoulou A, Rees AF, Tomas J, Turkozan O (2018) Mediterranean sea turtles: current knowledge and priorities for conservation and research. *Endangered Species Research* 36:229-267
17. Casale, P. (2011). Sea turtle by-catch in the Mediterranean. *Fish and Fisheries*, 12(3), 299-316.
18. Casale, P., & Margaritoulis, D. (2010). Sea turtles in the Mediterranean: Distribution. Threats and Conservation Priorities. IUCN, Gland, Switzerland.
19. Casale, P., & Mariani, P. (2014). The first 'lost year 'of Mediterranean sea turtles: dispersal patterns indicate subregional management units for conservation. *Marine Ecology Progress Series*, 498, 263-274.
20. Casale, P., Broderick, A. C., Freggi, D., Mencacci, R., Fuller, W. J., Godley, B. J., & Luschi, P. (2012). Long-term residence of juvenile loggerhead turtles to foraging grounds: a potential conservation hotspot in the Mediterranean. *Aquatic Conservation*: *Marine and Freshwater Ecosystems*, 22(2), 144-154.

21. Casale, P., Broderick, A.C., Camiñas, J.A., Cardona, L., Carreras, C., Demetropoulos, A., Fuller, W.J., Godley, B.J., Hochscheid, S., Kaska, Y. & B., Lazar. (2018). Mediterranean sea turtles: current knowledge and priorities for conservation and research. *Endangered Species Research*, 36, 229-267.

22. Casale, P., Freggi, D., Gratton, P., Argano, R., & Oliverio, M. (2008). Mitochondrial DNA reveals regional and interregional importance of the central Mediterranean African shelf for loggerhead sea turtles (*Caretta caretta*). *Scientia Marina*, 72(3), 541-548.

23. Clusa, M., Carreras, C., Pascual, M., Demetropoulos, A., Margaritoulis, D., Rees, A.F., Hamza, A.A., Khalil, M., Aureggi, M., Levy, Y. & Türkozan, O. (2013). Mitochondrial DNA reveals Pleistocenic colonisation of the Mediterranean by loggerhead turtles (*Caretta caretta*). *Journal of Experimental Marine Biology and Ecology*, 439, 15-24.

24. Demetropoulos, A. & M. Hadjichristophorou (1995): Manual on Marine Turtle Conservation in the Mediterranean. – UNEPMAP-RACSPA /IUCN / CWS/ Fisheries Department. Manre, Cyprus.

25. Erk'akan, F. (1993). Nesting biology of loggerhead turtles *Caretta caretta* L. on Dalyan beach, Mugla-Turkey. *Biological Conservation*, 66(1), 1-4.

26. Garofalo, L. (2010). The Genetics of the loggerhead turtle (*Caretta caretta*) in Italy: from scientific data to public knowledge. PhD thesis. University of Rome.

27. Garofalo, L., Mingozzi, T., Micò, A., & Novelletto, A. (2009). Loggerhead turtle (*Caretta caretta*) matrilines in the Mediterranean: further evidence of genetic diversity and connectivity. *Marine Biology*, 156(10), 2085-2095.

28. Godfrey M.H, Barreto R. & N., Mrosovsky (1997) Metabolically generated heat of developing eggs and its potential effect on sex-ratio of sea turtle hatchlings. *Journal of Herpetology* 31:616–619

29. Godley B.J ., Broderick A. C., Glen F., & G. C., Hays (2002) Temperature dependent sex determination of Ascension Island green turtles. *Marine Ecology Progress Series* 226: 115-124.

30. Godley, B. J., Blumenthal, J. M., Broderick, A. C., Coyne, M. S., Godfrey, M. H., Hawkes, L. A., & Witt, M. J. (2008). Satellite tracking of sea turtles: where have we been and where do we go next?. *Endangered Species Research*, 4(1-2), 3-22.

31. Godley, B. J., Richardson, S., Broderick, A. C., Coyne, M. S., Glen, F., & Hays, G. C. (2002). Long-term satellite telemetry of the movements and habitat utilisation by green turtles in the Mediterranean. *Ecography*, 25(3), 352-362.

32. Hadoud D.A. & H. El Ghmati. 1996. The coastal survey of marine turtle activity along the coast of Libya. Phase 2: between Sirte and Misratah. MBRC Report. 22pp.

33. Hamza A (2010) Libya. In: Casale P, and Margaritoulis D, eds. Sea Turtle in the Mediterranean Sea Distribution, threats and conservation priorities. Gland, Switzerland: IUCN, 157-170.

34. Hamza A. & H. El Ghmati (2006) Conservation of Marine Turtles nesting at Three Sites West of Sirte, Libya. Final report. The Regional Activity Centre for Specially Protected Areas (UNEP-MAP-RAC/SPA), Tunis. Pp35.

35. Hamza, A. (2007) Marine Turtle Nesting activity and conservation, Sirte-Libyan Arab Jamahiriya (2006 season). Final report. The Regional Activity Centre for Specially Protected Areas (UNEP-MAP-RAC/SPA), Tunis. Pp32.

36. Hamza, A., Swayeb, B., & Deryag, S. (2009). Sea Turtles Tagging in Libya. *Marine Turtle Newsletter*, (125), 7.

37. Hassine, S. B., Jribi, I., Bradai, M. N., Bouain, A., & Girondot, M. (2011). The Origin in Variability of Nesting Period of the Loggerhead Turtle (*Caretta caretta*) in the Kuriat Islands, Tunisia. *Marine Turtle Newsletter*, 131, 48-50.

38. Hawkes, L. A., Broderick, A. C., Coyne, M. S., Godfrey, M. H., & Godley, B. J. (2007). Only some like it hot—quantifying the environmental niche of the loggerhead sea turtle. *Diversity and Distributions*, 13(4), 447-457.

39. Hawkes, L. A., Witt, M. J., Broderick, A. C., Coker, J. W., Coyne, M. S., Dodd, M., Godfrey M.H, Griffin D.B, & Murphy, T. M. (2011). Home on the range: spatial ecology of loggerhead turtles in Atlantic waters of the USA. *Diversity and Distributions*, 17(4), 624-640.

40. Hays, G. C., & Hawkes, L. A. (2018). Satellite Tracking Sea turtles: opportunities and challenges to address key questions. *Frontiers in Marine Science*, 5, 432.

41. Hays, G. C., Bradshaw, C. J. A., James, M. C., Lovell, P., & Sims, D. W. (2007). Why do Argos satellite tags deployed on marine animals stop transmitting?. *Journal of Experimental Marine Biology and Ecology*, 349(1), 52-60.

42. Hays, G. C., Fossette, S., Katselidis, K. A., Mariani, P., & Schofield, G. (2010). Ontogenetic development of migration: Lagrangian drift trajectories suggest a new paradigm for sea turtles. *Journal of the Royal Society Interface*, 7(50), 1319-1327.

43. Hays, G. C., Speakman, J. R., & Hayes, J. P. (1992). The pattern of emergence by loggerhead turtle (*Caretta caretta*) hatchlings on Cephalonia, Greece. *Herpetologica*, 396-401.

44. Herbert, J. (1979). Kouf National Park: Wildlife survey and development. The Arab center for the studies of arid zones and dry lands. Unpublished Technical Report.

45. Hirth, H. F. (1980). Some aspects of the nesting behavior and reproductive biology of sea turtles. *American Zoologist*, 20(3), 507-523.

46. Hochscheid S, Bentivegna F, Saied A, Hamza A, Dryag SMH, Bradai MN, Jribi I, Swayeb B, Ghmati H, Mifsud C, Sammut C, Gruppetta A, Kaska Y, Ouerghi A (2011) 10 years of satellite tracking marine turtles in the Mediterranean: Review on a multi-national project. In: Bentivegna F, Maffucci F, Mauriello V (eds) *Fourth Mediterranean Conference on Marine Turtles, Napoli, Italy*

47. Hochscheid, S., Aksissou, M., Arapis, T., Benabdi, M., Boura, L., Broderick, A., Cardona, L., Carreras, C., Claro, F., Demetropoulos, A., Fuller, W.J., Jribi, I., Kaska, Y., Levy, Y., Maffucci, F., Margaritoulis, D., Mifsud, C., Panagopoulou, A., Sacchi, J., Tomás, J., Türkozan, O., & A. Rees (2019) Seaturtles of The Mediterranean Sea. SWOT, Vol XIV :20-29.

48. Hochscheid, S., Bentivegna, F., Bradai, M. N., & Hays, G. C. (2007). Overwintering behaviour in sea turtles: dormancy is optional. *Marine Ecology Progress Series*, 340, 287-298.

49. Jribi I. & M.N. Bradai, 2017. Suivi de la nidification de la tortue marine *Caretta caretta* sur les îles Kuriat (Campagne 2017). Convention ANPE - CAR/ASP - INSTM (2017) : 20 pp.

50. Jribi I., Ben Hassine S., Bradai, M.N. & A., Bouain (2008) Estimating hatchling sex ratios of loggerhead turtles from incubation duration and nest temperatures at Kuriat island, Tunisia. *Proceedings of the third Mediterranean Marine Turtle Conference. Hammemet, Tunisia*: 21-23 Oct. 2008.

51. Jribi, I., Bradai, M. N., & Bouain, A. (2002). Marine turtle nesting in Kuriat islands, Tunisia, 2000. *Marine Turtle Newsletter*, 96, 4-6.

52. Jribi, I., Bradai, M. N., & Bouain, A. (2006). Loggerhead Turtle Nesting Activity in Kuriat Islands(Tunisia): Assessment of Nine Years Monitoring. *Marine Turtle Newsletter*, 112, 12-13.

53. Jribi, I., Bradai, M. N., & Bouain, A. (2007). Impact of trawl fishery on marine turtles in the Gulf of Gabes, Tunisia. *The Herpetological Journal*, 17(2), 110-114.

54. Jribi, I., Echwikhi, K., Bradai, M. N., & Bouain, A. (2008). Incidental capture of sea turtles by longlines in the Gulf of Gabes (South Tunisia): a comparative study between bottom and surface longlines. *Scientia Marina*, 72(2), 337-342.

55. Jribi, I., Hamza, A., Saied, A., & Ouergui, A. (2013). Sex ratio estimations of loggerhead marine turtle hatchlings by incubation duration and nest temperature at Sirte beaches (Libya). *Scientia Marina*, 77(4), 617-624.

56. Karaa, S., Maffucci, F., Jribi, I., Bologna, M.A., Borra, M., Biffali, E., Bradai, M.N. and Hochscheid, S. (2016). Connectivity and stock composition of loggerhead turtles foraging on the North African continental shelf (Central Mediterranean): implications for conservation and management. *Marine Ecology*, 37(5), 1103-1115.

57. Kaska Y. (2000) Predation pattern of loggerhead and green turtle nests in the Eastern Mediterranean and its possible effect on sex-ratio. *Isr. J. Zool*. 46:343–349

58. Kaska Y., Downie R., Tippett R., & R. W., Furness (1998) Natural temperature regimes for Loggerhead and Green turtle nests in the Eastern Mediterranean. Canadian *Journal of Zoology*, 76 : 723-729.

59. Kaska Y., Robert W. F., & I., Baran (1998) Sex ratio of hatchlings in nest can be estimated from the mean temperature during the middle third of incubation. *Proceedings of the 18th International Symposium on sea turtle Biology and Conservation*. 74-76.

60. Laurent, L. Bradai, M. N.Hadoud, D., El Gomati, H. M. & A. A., Hamza (1999) Marine turtle nesting activity assessment on Libyan coasts. Phase 3: Survey of the coast to the west of Misratah Joint Project of: Marine Biology Research Centre (Tajura, Libya), MEDASSET, RAC/SPA (MAP-UNEP), TCEP (Tripoli), WWF International Mediterranean Programme; 1999, 47 pp.

61. Laurent, L., & Lescure, J. (1994). L'hivernage des tortues caouannes *Caretta caretta* (L.) dans le sud Tunisien. *Revue d'écologie* 49:63-86

62. Laurent, L., Casale, P., Bradai, M.N., Godley, B.J., Broderick, G.G.A.A., Schroth, W., Schierwater, B., Levy, A.M., Freggi, D., Abd El-Mawla, E.M. And Hadoud, D.A., (1998). Molecular resolution of marine turtle stock composition in fishery bycatch: a case study in the Mediterranean. *Molecular Ecology*, 7(11), 1529-1542.

63. Laurent, L., M. N. Bradai, D. A. Hadoud, and H. E. Gomati. (1995). Marine turtle nesting activity assessment on Libyan coasts. Phase 1. Survey of the coasts between the Egyptian border and Sirte. Tunis: UNEPMAP- RAC/SPA.

64. Laurent, L., M.N. Bradai, D.A. Hadoud & H.M. El Gomati (1997) Assessment of sea turtle nesting activity in Libya. *Marine Turtle Newsletter* 76: 2-6.

65. Maffucci, F., Kooistra, W. H. C. F., & Bentivegna, F. (2006). Natal origin of loggerhead turtles, *Caretta caretta*, in the neritic habitat off the Italian coasts, Central Mediterranean. *Biological Conservation*, 127(2), 183-189.

66. Marcovaldi, M. A., Godfrey, M. H., & N., Mrosovsky (1997) Estimating sex ratios of loggerhead turtles in Brazil from pivotal incubation temperatures. *Canadian Journal of Zoology*. 75, 755-770.

67. Margaritoulis, D. (1982). Observations on loggerhead sea turtle *Caretta caretta* activity during three nesting seasons (1977–1979) in Zakynthos, Greece. *Biological Conservation*, 24(3), 193-204.

68. Margaritoulis, D., R. Argano, I. Baran, F. Bentivegna, M.N. Bradai, J.A. Caminas, P. Casale, G. De Metrio, A. Demetropoulos, G. Gerosa, B.J. Godley, D.A. Haddoud, J. Houghton, L. Laurent & B. Lazar (2003) Loggerhead turtles in the Mediterranean Sea: present knowledge and conservation perspectives. In: Bolten AB & B.E. Witherington (Eds.) Loggerhead sea turtles. Smithsonian Institution Press, Washington, DC, p 175–198.

69. Monzón-Argüello, C., Rico, C., Naro-Maciel, E., Varo-Cruz, N., López, P., Marco, A., & López-Jurado, L. F. (2010). Population structure and conservation implications for the loggerhead sea turtle of the Cape Verde Islands. *Conservation Genetics*, 11(5), 1871-1884.

70. Moritz, C. (1994). Defining 'evolutionarily significant units' for conservation. *Trends In Ecology & Evolution*, 9(10), 373-375.

71. Mrosovsky N. & C., Pieau (1991) Transitional range of temperature, pivotal temperatures and thermosensitive stages for sex determination in reptiles. *Amphibia-Reptilia* 12, 169-179.

72. Mrosovsky N. & C.L., Yntema (1980) Temperature dependence of sexual differentiation in sea turtles: implications for conservation practices. *Biological Conservation* 18: 271–280.

73. Mrosovsky N., Camel S., Rees A.F. & D., Margaritoulis (2002) Pivotal temperature for loggerhead turtles (*Caretta caretta*) from Kyparissia Bay, Greece. *Canadian Journal of Zoology*, 80:2118-2124.

74. Nielsen, J.T. (2010) Population Structure and the Mating System of Loggerhead Turtles (*Caretta caretta*). Open Access Dissertations. Paper 507., University of Miami

75. Öz M., Erdogan, A., Kaska, Y., Düsen, S., Aslan, A., Sert, H., Yavuz, M., & M.R., Tunç (2004) Nest temperatures and sex-ratio estimates of loggerhead turtles at Patara beach on the southwestern coast of Turkey. *Canadian Journal of Zoology*. 82: 94–101

76. Rees A. F. & D. Margaritoulis (2005) Beach temperatures, incubation duration and estimated hatchling sex-ratio for loggerhead sea turtle nests in southern Kyparyssia Bay , Greece. B.C.G. *Testudo* Vol. 6, No. 1 : 23-36

77. Saied A., Hamza. A, Bourass E., Deryagh S., Bowena E., Elshater M., Doufani K. & A., Basheyah (2008) Nesting Activity and Conservation of marine Turtles in Three Nesting Sites West of Sirte (results of 2006-2007 seasons). *Proceedings of the Third Mediterranean Marine Turtle Conference. Hemmemet, Tunisia*: 21-23 Oct. 2008.

78. Saied, A., Maffucci, F., Hochscheid, S., Dryag, S., Swayeb, B., Borra, M., Ouerghi, A., Procaccini, G. and Bentivegna, F. (2012). Loggerhead turtles nesting in Libya: an important management unit for the Mediterranean stock. *Marine Ecology Progress Series*, 450, 207-218.

79. Schleich H. (1987) Contributions to the herpetology of Kouf National Park (NE-Libya) and adjacent areas. *Spixiana* 10 (1):37-80.

80. Schleich, H. (1984) Studies on the herpetology of the Kouf National Park and adjacent areas of Cyrenaica. IUCN, Gland

81. Shamblin, B.M., Bolten, A.B., Abreu-Grobois, F.A., Bjorndal, K.A., Cardona, L., Carreras, C., Clusa, M., Monzón-Argüello, C., Nairn, C.J., Nielsen, J.T. and Nel, R. (2014). Geographic patterns of genetic variation in a broadly distributed marine vertebrate: new insights into loggerhead turtle stock structure from expanded mitochondrial DNA sequences. *PLoS One*, 9(1), e85956.

82. Snape, R. T., Broderick, A. C., Çiçek, B. A., Fuller, W. J., Glen, F., Stokes, K., & Godley, B. J. (2016). Shelf life: neritic habitat use of a turtle population highly threatened by fisheries. *Diversity and Distributions*, 22(7), 797-807.

83. UNEP MAP RAC/SPA (2007) Action Plan for the Conservation of Mediterranean Marine Turtles. RAC/SPA, Tunis, Tunisia. 40pp.

84. UNEP-MAP-RAC/SPA (2003) The National Action Plan of Marine Turtles and Their Habitats in Libya.

85. Yntema C. L. & N., Mrosovsky (1980) Sexual differentiation in hatchling loggerheads (*Caretta caretta*) incubated at different controlled temperatures. *Herpetologica*, 36 (1) : 33 – 36.

86. Zbinden, J. A., Aebischer, A., Margaritoulis, D., & Arlettaz, R. (2008). Important areas at sea for adult loggerhead sea turtles in the Mediterranean Sea: satellite tracking corroborates findings from potentially biased sources. *Marine Biology*, 153(5), 899-906.

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Specially Protected Areas Regional Activity Centre (SPA/RAC)
Boulevard du Leader Yasser Arafat - B.P. 337 - 1080 Tunis Cedex - Tunisia
Tel: +216 71 206 649 / 485 | car-asp@spa-rac.org | www.spa-rac.org