Injuries in nesting females of Cape Verde loggerhead colony

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ABSTRACT

Natural threats in marine turtles are well known and have an important impact in the first stages of their life cycle. The International Union for Conservation of Nature (IUCN) classifies the loggerhead sea turtle (*Caretta caretta*) as an endangered species due to the important reduction of their population's sizes worldwide. In this work, we pretend to analyze main injuries observed in Cape Verde loggerhead nesting females in order to identify main threats and impacts affecting this colony, just like possible temporal trends. There have been studied 11.090 loggerhead-nesting females localized during the nesting process, on the south-eastern beaches of Boa Vista Island (Cape Verde), from 2005 to 2015 nesting seasons. Data used for this study come from the database collected by Cabo Verde Natura 2000 NGO from 1998. Turtle injuries were classified into two main groups: "Carapace lesions" subdivided into, carapace fracture, shark attack, barnacle holes, small lesions and undetermined lesions. The second group include the flippers lesions, subdivided into front flipper and rear flipper lesions. The studying area comprises 20 Km of nesting beaches hosting the highest nest densities in the Archipelago and included in two Protected Areas (*Reserva Natural das Tartarugas* and *Parque Natural do Norte*). The area was divided into four zones for the analysis. The results indicate small variations in the frequencies of the lesions analysed along the years, between zones and in relation with the carapace length. Finally, the effect of flipper amputation in nesting success was analysed, identifying an important negative impact on the reproductive success of the colony.

Keywords: Loggerhead, Cape Verde, injuries, threats, impacts, nesting success.

INDEX

1. INTRODUCTION

1.1 The loggerhead turtle

Currently, 2 families and 7 species of sea turtles are recognized (Pritchard 1997). The family Cheloniidae comprises the green turtle (*Chelonia mydas)*, loggerhead (*Caretta caretta)*, hawksbill (*Eretmochelys imbricata)*, Kemp's ridley (*Lepidochelys kempi)*, olive ridley (*Lepidochelys olivacea)* and flatback (*Natator depressus)*. The family Dermochelyidae comprises only the leatherback (*Dermochelys coriacea)* (Orós *et al*., 2001).

Members of the Cheloniidae family preferentially live in tropical or subtropical waters, where are localized the most part of the nesting beaches, although some loggerhead' nesting beaches are housed in temperate areas. The Dermochelyidae family, currently represented by a single species, shows very different characters from the rest of species, related to the ecological used (Mateo *et al*., 1997).

Loggerhead turtle (*Caretta caretta* Linnaeus, 1758) (Fig.1), is a marine Reptile from the Order Chelonia Suborder Cryptodira (Table 1), commonly called "loggerhead" due to their large head in comparison with other species.

Loggerheads spend the majority of their lives in a marine environment, occurring within both near-shore (neritic) waters and offshore (oceanic) waters. Loggerhead turtle is a highly migratory specie, so their distribution and behaviour are invariably linked to the environment which is influenced by physical processes and subject to shifting temperatures, currents, habitats, and prey availability (Wyneken *et al*., 2013).

Domain	Eukarya
Kingdom	Animalia
Subkingdom	Eumetazoa
Phylum	Chordata
Subphylum	Vertebrata
Superclass	Tetrapoda
Class	Reptilia
Order	Testudines
Suborder	Cryptodia
Family	Cheloniidae
Genus	*Caretta*
Specie	*Caretta caretta*

Table 1. Scientific Classification of *Caretta caretta*

This species is known as loggerhead because of their relatively large heads (reaching 28 cm in adults), which support powerful jaws and allow them to feed on preys of hard shells. It is mainly carnivorous, which includes in its diet a wide range of taxa including fish, crustaceans, porifera, molluscs, cephalopods, echinoderms and other benthic invertebrates (Bjorndal, 1997; Tomas *et al*., 2002).

Their toothless horny beak, V-shaped and robust jaws and strong musculature allow them to ingest food with hard structures, grinding the hard carapaces or shells. They also have a relatively long secondary palate with no alveolar ridges and the two maxillary bones come in posterior contact with the premaxillary bones (Lutz *et al*., 2003 and Wyneken, 2004).

In adults, the dorsal color of carapace and head is reddish brown and the plastron is lighter than the carapace with diffuse dark margins. However, in hatchlings, the color of the dorm is dark brown or reddish brown and the plastron may vary color from creamy white to reddish to dark brown (Bolten *et al*., 2003).


Figure. 1. Loggerhead turtle images: a) Adult loggerhead, b) Hatchling loggerhead. Source: National Marine Life Center.

The loggerhead carapace has five vertebral scutes, usually five pairs of costal scutes, but four pairs and other anomalous scute arrangements are occasionally observed. The first costal is the smallest and the third is the largest. Three pairs of infra marginal scutes are present, which are not perforated by pores, and a small intergular and a small anal scutes are sometimes present on the anterior and posterior of the plastron respectively (Bolten *et al*., 2003).

According to data collected from the National Oceanic and Atmospheric Administration (NOAA) the USA loggerhead colonies ranged from 82 to 105cm in straight carapace length (SCL) and adults can reach 180 kg in weight. Hatchlings do not exceed 20 g and are approximately 45 mm long. However, according to data collected by Cabo Verde Natura 2000 NGO, the Capeverdean loggerhead colony is smallest that the USA colonies, ranging from 60 to 100cm in curved carapace length (CCL) (Varo Cruz, 2010).

Although they develop their life in the marine environment, the females lay their eggs in land. As in the other marine turtle species, tagging studies demonstrate that the vast majority of nesting females return to the same area for nesting and use the same foraging areas between reproductive migrations (Limpus *et al*., 1992). Even more, they are philopatric animals or present a natal homing behaviour, that is, they return to the same beaches where they were born (Miller, 1997).

The loggerhead life cycle begins at the nesting beaches where the female leaves the sea to lay eggs in nests excavated in the sand. Embryonic development takes approximately 2 months. Then neonates emerge to the surface, reach the shore and go into the depth sea. The movements and distribution patterns of small turtles are strongly influenced by oceanographic and meteorological factors (Bolten *et al*., 2003).

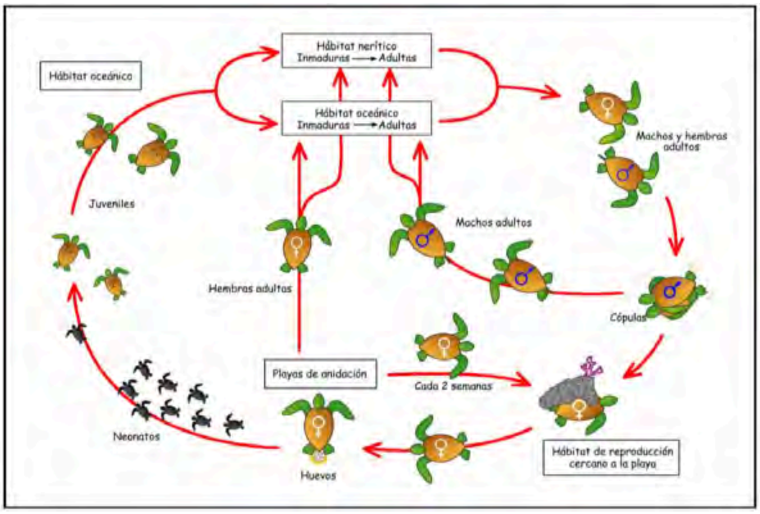


Figure 2. Loggerhead life cycle (modified from Bolten *et al*., 2003)

Loggerhead turtle spend their entire juvenile stage in oceanic waters, unlike green and hawksbill turtles that recruit to neritic habitats in the middle of their juvenile period (3-6 years old) (Bolten *et al*., 2003) (Fig.2). The juvenile oceanic stage is commonly called "*lost years*" because their movements and migrations in the open ocean have been and remain quite unknown (Bolten *et al*., 2003). Normally, larger juveniles or sub-adults recruit to neritic habitats, at around 54cm in CCL, where they reach the maturity and start their adult stage migrating between reproductive and adult foraging habitats (Bolten *et al*., 2003). Although, several loggerhead colonies never recruit to neritic habitats, even when they are adults, as the rockeries of Cape Verde or Japan (Hawkes *et al*., 2006).

Courtship and copulation appear to be confined to a period of several weeks prior to nesting (Miller, 1997), so copulations can occur during migration, while they migrate from feeding areas to nesting areas (Casale and Tucker, 2015), or in the breeding areas located in front of the nesting beaches (Limpus *et al*., 1992; Plotkin, 2003), During courtship the male tries to mount the female, which receive bites mainly on the neck and shoulders before being mounted. Males hold the females with their front flippers nails, scratching them on their shoulders and flippers (Miller *et al*., 2003).

The nesting season runs from June to October, reaching its peak in August and September. Generally, loggerhead females take several years to re-nest or rarely breed annually (Hamann *et al*., 2003; Miller *et al*., 2003) due to the high energetic cost of reproduction and migration. However, males may reproduce annually (Wibbles *et al*., 1990; Hamann *et al*., 2003; Hays *et al* 2010). Nevertheles, females usually nest several times over a nesting season (Varo-Cruz, 2010).

The clutch size or mean number of eggs per nest, usually ranges between 75 and 135 eggs (Margaritoulis *et al*., 2003), but varies between rockeries and/or colonies. Depending on the population, incubation period of loggerhead nests usually takes between 50 and 69 days (Dodd, 1990; Márquez, 1990), which is temperature dependent or influenced. Higher temperatures decrease the incubation period and lower temperatures increase the incubation time (Bustard and Greenham 1968; Ackerman and Prange 1972; Mrosovsky 1988). The range of viable temperatures for egg development is approximately 25-34 °C (Yntema and Mrosovsky 1980; Miller *et al*., 2003). Moreover, hatchling's sex is also temperature dependent (Yntema and Mrosowsky, 1980), where the pivotal temperature (PT), which produces half males and half females, is approximately 29°C for the loggerhead turtle, although there may be small differences between populations (Mrosovsky *et al*., 2002; Mrosovsky *et al*., 2009). Cooler incubation temperatures produce higher males proportions and warmer temperatures produce more females.
Marine turtles are active swimmers and divers who spend the most part of their lives (95%) on the surface of the water column (first 5 meters). Loggerhead turtle spend around 20 minutes diving when are actively swimming or looking for food, but they could spend more than 1 hour underwater when they are relaxed. In normal conditions they use the anterior flippers to propel themselves, while the posterior fins serve as a rudder to direct their movements (Wyneken *et al*., 2013).

1.2 The Cape Verde Loggerhead colony

The archipelago of Cape Verde is located about 500 km of Senegal, Central-East Atlantic (Fig. 3). The total area is 4,033 km^2. It is composed of 10 volcanic islands which are divided into two groups: Windward island (Ilhas de Barlovento) composed by Santo Antão, São Vicente, Santa Luzia, São Nicolau, Sal and Boavista; and Leeward islands (Ilhas de Sotavento) comprised by Maio, Santiago, Fogo and Brava. Both groups include several small islets (Varo-Cruz, 2010). After being populated, the islands were subjected to an intense exploitation of the resources. In the marine environment, human pressure has been exerted on several marine populations such us whales and turtles, hunting them for consumption.

The Cape Verde Islands host the third largest nesting population of loggerhead turtle in the world, behind the southeast coast of North America (Florida, North and South Carolina and Georgia) (Marco et al., 2010, 2012). In other hand, the Cape Verde loggerhead colony represents one of the eleven most threatened populations in the world (*Wallace et al*., 2011; IUCN, 2015).

Boa Vista is the eastern island and may constitute the most important nesting area for the loggerhead turtle in the archipelago (80% of the nests).

Figure. 3. Map of Cape Verde, Boa Vista island. Google Earth

Cabo Verde Natura 2000 has conducted biodiversity conservation and protection activities in Boa Vista from 1998, mainly focused on marine turtles, marine mammals and seabirds. Each season, the camps receive volunteers interested in knowing and working for conservation, protection and investigation of loggerhead turtles reproduction.

The activities carried out in the Field Camps of the CVNat2000 NGO, are: tagging and biometric data collection of nesting females, nests monitoring, daily census, relocation of endangered nests to optimal locations, and collaboration in awareness activities with Boa Vista local population.

The increasing pressure on this region due to the explosive growth of mass tourism could have a great impact on the conservation state of this important rockery (Crespo-Picazo *et al*., 2013).

In Cape Verde, each year increasing numbers of injured females are observed, for both anthropogenic and natural causes.

1.3 Main sea turtles threats

Natural threats in marine turtles are well known and have an important impact in the first stage of their life cycle. The most important is the high levels of predation on eggs and hatchlings.

In other hand, sea turtles are subject to human induced mortality during all their life stages. On land, nesting females, incubated eggs, and emerging hatchlings may be impacted, incidentally, such as disorientation by lights or debris disturbance on the beach; or intentional by direct harvest of adults and eggs. Around the world the loggerhead turtle is little pursued for their meat, and although their eggs are poached in some parts of the world, direct take for human consumption is not a major factor in its survival prospects (Luzt *et al*., 1996). Although, Cape Verde loggerhead' rockery is still suffering this direct impact (Marco *et al*., 2012).

The International Union for Conservation of Nature (IUCN) classifies the loggerhead sea turtle (*Caretta caretta)* as an endangered species (Marine Turtle Specialist Group, 2015) due to the important reduction of their population's sizes worldwide.

The environment that marine turtles occupy predisposes them directly to some of the pathological processes with which they must contend, such us be part of the diet of some species of sharks, where the white shark (*Carcharodon carcharias*) and the tiger shark (*Galeocerdo cuvier*) are the species most studied (Marquez, 1990). White shark may be the main marine predator of juvenile and adult chelonians, although the impact of this predation on turtle populations is minimal compared to other mortality sources (Witzell 1987; Simpfendorfer *et al*., 2001).

In addition to shark predation, there are others natural factors such us cliff falls when females came back to the sea after nesting, causing fractures in the carapace or head and flipper injuries. The loss of adult females can have a great impact on the future of the population (Wyneken *et al*., 2008).
Once turtles are in the water, a vast variety of new sources of impact are brought to bear. These include pollution and marine debris, habitat degradation, direct harvest, and incidental capture by a variety of sources, including fishing and dredging.

As a result of grew of annual global production of plastics from 1,5 million tons to 299 million tons between 1950 and 2015, the abundance and spatial distribution of *plastic pollution*, both on land and at sea, are increasing (Barnes *et al*., 2009; Jambeck *et al*., 2015). Indeed, plastic items have become the principal constituent of marine debris, the majority originating from land-based sources, such as landfill sites, with the remaining deriving from human activities such as fishing (Barnes *et al*., 2009; Ivar do Sul *et al*., 2011). Several studies show that all the seven species are known to ingest or become entangled in marine debris. Ingestion can cause intestinal blockage and internal injury, dietary dilution, malnutrition, and increased buoyancy, which can result in poor health, reduced growth rates and reproductive output, or death. Entanglement in plastic debris (including ghost fishing gear) is known to cause lacerations, increased drag—which reduces the ability to forage effectively or escape threats—and may lead to drowning or death by starvation. In addition, plastic pollution may impact turtle habitats hot spots. In particular, marine debris presence on nesting beaches may alter nest properties by affecting temperature and sediment permeability. This could influence hatchling sex ratios and reproductive success, resulting in population level implications (S. E. Nelms *et al*., 2016).

Another important threat for sea turtles is the incidental capture on fishing gears or *by-catch*. Along the last 20 years a great effort was conducted to collect information about the by-catch in all sea turtles and mainly on loggerhead turtles. By-catch rates vary substantially in space and time, in part because of different gear configurations and fishing practices but also due to turtle and fishing vessel movement. For example, in the Pacific tuna fleet, the Inter-American Tropical Tuna Commission (IATTC) estimates that only the high seas industrial tuna fisheries slake about 200 million hooks each year, where they recognize that they catch turtles incidentally. Although by-catch rates from individual long-line vessels are extremely low, the amount of gear deployed by long-line vessels suggests that cumulative by-catch of turtles from older age classes is substantial. Current estimates suggest that even if pelagic long-lines are not the largest single source of fisheries-related mortality, long-line by-catch is high enough to warrant management actions in all fleets that encounter sea turtles. Nevertheless, preliminary data also suggest that by-catch from gillnets and trawler fleets is equally high or higher than long-line by-catch with far higher mortality rates (Lewison *et al*., 2007).

Recent studies point out that circle hooks and mackerel bait have demonstrated promise in reducing by-catch of some sea turtles in the Northwest Atlantic long-line fleet (Watson *et al*., 2005; Gilman *et al*., 2006).

When a turtle is trapped in nets, is difficult to escape without injuries, most of them extremely important such us flipper amputations (partial or total) or important cuts, which make it difficult to swim and increases mortality. Therefore, scientists and fishermen have developed new techniques that reduce incidental turtle by-catch and/or decreasing damages, which are also acceptable to the fishing industry. Some examples are: use a large circular hook, to prevent the turtle from getting caught; drive long-lines at greater depth (> 40m); use fish as bait instead of squid (fish can easily get out of hook while the turtle bite it); or avoid areas with many turtles (Lutz *et al*., 2002) (Fig. 4). Also turtle mortality may be decreased by closing an area to trawling or by reducing tow times. Other important technical solution is the turtle excluder device (TED) that incorporates a trapdoor in the trawl to allow sea turtles to escape from the nets (Lutz *et al*., 2002).

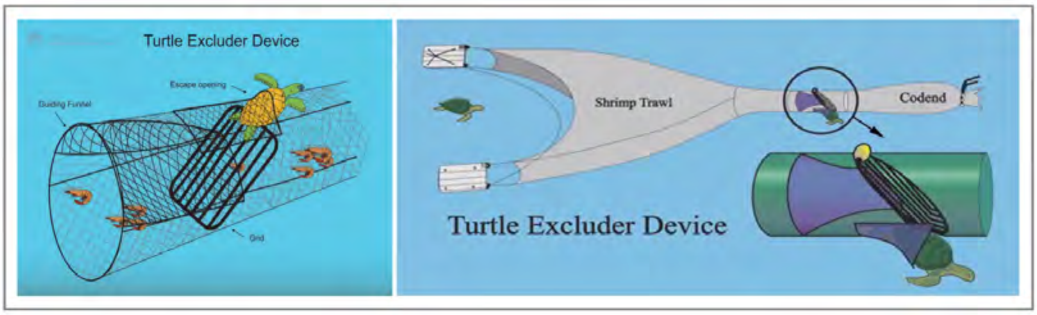


Figure. 4. Turtle Excluder Devices (TEDs). Source: NMFS Mississippi Laboratories.

Sea turtles spend a great proportion of their time (95%) on the surface to breathe and rest between dives. At this time they are vulnerable to ***boat strikes***, particularly from speedboats. The effect of boat strikes is of great concern in turtle frequented waters with dense tourist activities because this turtles die or are severely affected from the lesions associated with this impact. Boat strikes can cause several types of injuries when striking with the keel or propellers (Orós *et al*., 2005; Work *et al*., 2010). In general, boat strikes cause serious fractures in the turtle's carapace that will change or affect their mobility, or could confuse the animal with a big blow, or broke their carapace in different pieces. Usually, boat strike does not affect large numbers of turtles, but the mortality rate of turtles affected by boat strikes is really high, if not the highest (Orós *et al*., 2001).

The effects of ***oil pollution*** are not known in detail, although small size specimens can be immobilized and exhausted by heavy oil pollution. Twenty out of ninety-nine loggerheads, examined in the Maltese islands, were found contaminated mostly with crude oil (Gramentz, 1988).

In addition, debris has been identified as harmful to sea turtles. Discarded nets, nylon bags, various buoyant plastics are of main concern. Special attention should be given to floating plastics and tar balls, which are frequently mistaken by turtles for food items (Orós *et al*., 2001).

1.4 Objectives

This study aim to analyse the main injuries and lesions observed in Cape Verde loggerhead nesting females in order to identify main threats and impacts that are affecting this loggerhead colony.

Specific objetives:

- Identify main lesions presented by nesting females of the Cape verde loggerhead colony.
- Analyse the temporal and spatial trends of main injuries
- Try to identify main threats affecting this important loggerhead colony

Analyse the long-term effect of flipper amputations in nesting success

2. METHODOLOGY

2.1 Study site

The study was carried out in the Cape Verde archipelago, on the south-eastern Boa Vista Island (16°06′12″N 22°48′13″W), where the highest nest density is located (Fig. 5).

Figure. 5. Map of nest densities Boa Vista.

The study area were divided into 4 zones in relation with nest densities distribution:

Zone 1: *Ponta Cosme*, *Barrosa* and *Joao Barrosa* beaches

Zone 2: *Ervatão* and *Benginho beaches*

Zone 3: *Pai Simao*, *Calderinha*, *Manuel Felipe*, *Banco*, *Pedra do mar*, *Curralinho*, *Calheta de Pau*, *Calheta II*, *Calheta III*, and *Laiedo Texeira* beaches.

Zone 4: *Praia do Roque, Carreto, Praiona, Nho Martin, Mosquito, Pedra Fernanda, Calheta de Bruna, Bufador, Porto Ferreira, Flor, Figura* and *Simon nho Narda*.

Zones 1, 2 and 3 are included in the *Reserva Natural de Tartarugas* (RNT) Protected Area and Zone 4 is included in the *Parque Natural do Norte* (PNN) Protected Area (Figs. 6 and 7).

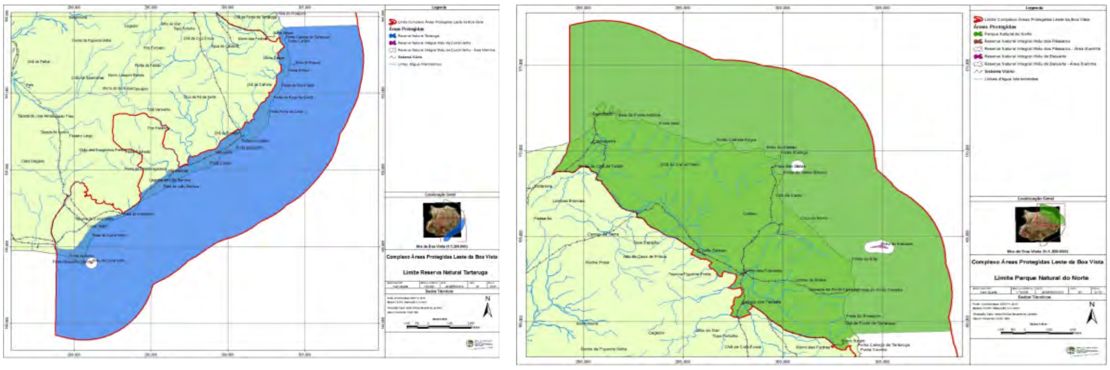


Figure. 6. Protected Areas where studied nesting beaches are included. *Reserva Natural das Tartarugas* (RNT) (left), *Parque Natural do Norte* (PNN) (right). Source: CVNat2000.

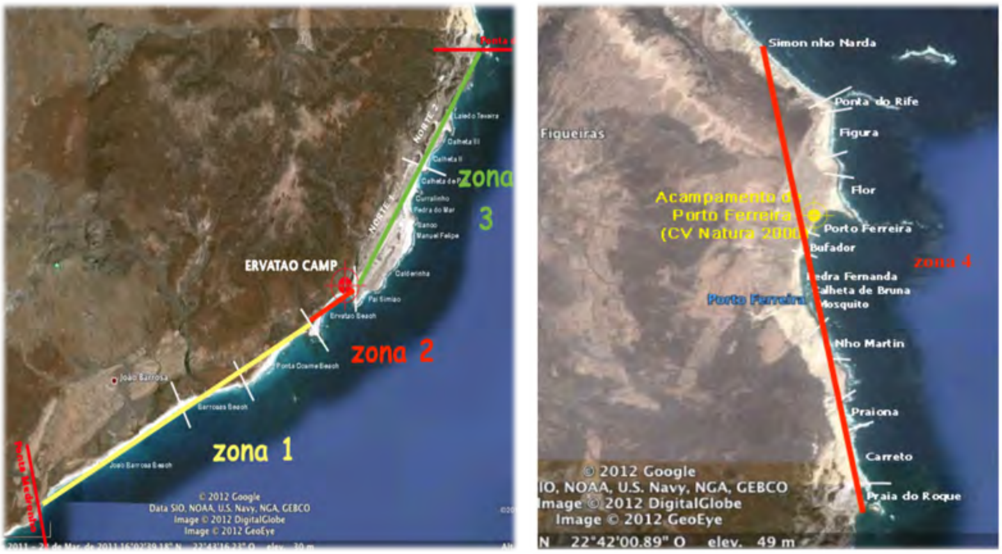


Figure. 7. Nesting beaches distribution and zones proposed for the study. Right: RNT beaches controlled by Ervatao Field Camp (CVNat2000); Left: PNN beaches controlled by Porto Ferrerira Field Camp (CVNat 2000).

2.2 Turtle data collection

For this study, there was used the database collected by Cabo Verde Natura 2000 NGO (CVNat2000) from 1998 to 2015. Data were collected each year during the nesting season (from June to October) in the most important nesting beaches of Boa Vista Island. Each year CVNat2000 installs 2 Field Camps where recruited staff and national and international volunteers came to support the conservation activities carried on with the loggerhead reproductive colony. During the night, teams composed by volunteers (1 to 3) and one Field assistant were distributed along the beaches to intercept nesting females during their nesting process.

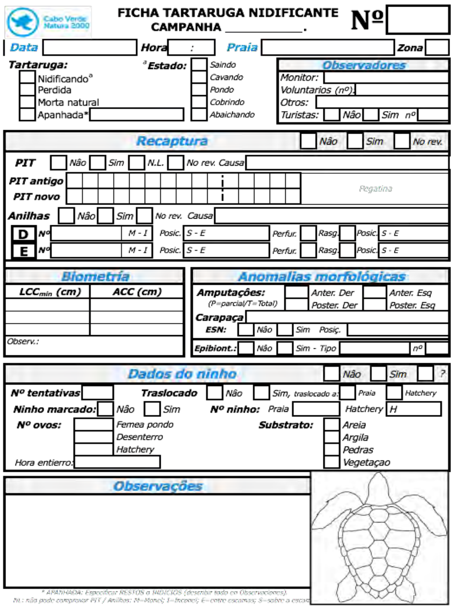
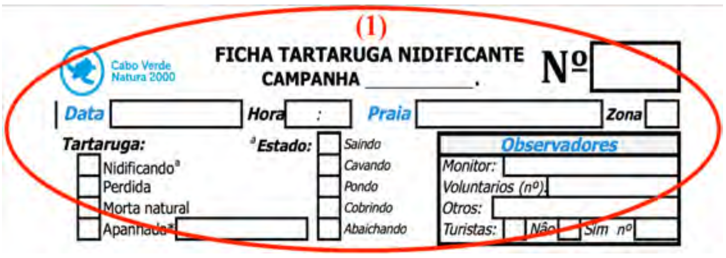


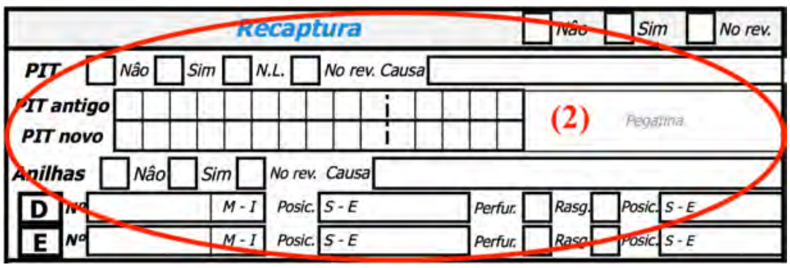
Figure. 8. Datasheet used by CVNat2000 in Boa Vista beaches to collect data..

The experimented Field assistant controlled every encounter to maintain the basic protocols to respect the nesting process and the turtle itself. Each turtle encounter is registered in datasheets, where all information about the turtles is collected (Figs. 8 to 13).

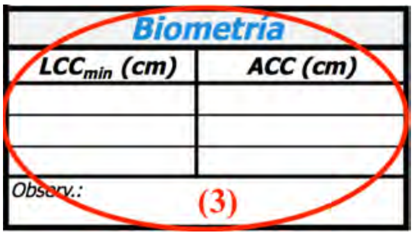
First part of the datasheet collects information about the *moment of the encounter* (date, time, beach, zone and circumstance of the encounter) and the *people collecting data* (1).



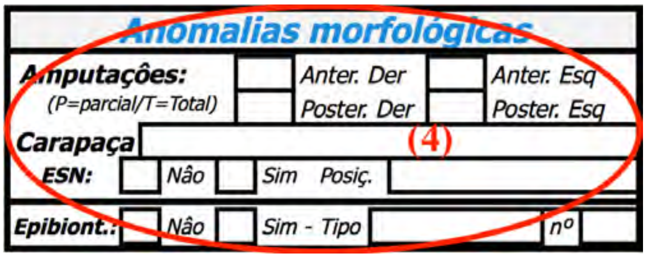
Besides, *tagging information* is registered, checking if the turtle had been tagged previously (with PIT or metal tags) and noting the number codes if is a recapture or the new ones if there is tagged in this moment (2).



Recapture information is very important in order to track each individual over the time, looking for their growth, nesting success, reproductive output, or even the apparition / evolution of injuries, lesions or anomalies.



Subsequently, there is collected the *biometry* of the turtle, through the minimum curved carapace length (CCLmin) and curved carapace width (CCW). These measures are taken 3 times to avoid possible errors (3).



Main goal of this study is collected as *Morphological anomalies*, where all injuries and anomalies are checked and registered, identi-fying flipper injuries, as partial or total amputations, and carapace lesions (4). Other anomalies, such us abnomal scute numbers (ESN), or epibionts presence is also noted.

Finally, data about the nesting process and nest characteristics are collected (presence of nest, attempts, if nest is translocated, identification of the nest, clutch size, and substrate composition) (5).

The datasheet has a scheme of the turtle to design all anomalies observed on the turtle (6).

2.3 Turtle injuries

Turtle injuries were classified into two main groups (Fig. 14):

1. **CARAPACE LESIONS:** when injuries are localized on the hard shell or carapace. Inside this group there were established different cases (Fig. 15):
   - *Carapace Fracture*: one or more large ruptures of the shell, longer than 15cm, usually caused by boats or propeller strickes or collisions.
   - *Shark attack*: identified as the lack of a semi-circular piece of carapace, greater than 15cm. In some occasions the typical teeth marks are appreciated, and sometimes the closest flipper is missing.

- *Barnacle holes*: oval or circular holes in the carapace, around 5 to 10cm long, caused by barnacles
- *Small lesions*: Lack of small pieces of the edges of the carapace, affecting marginal scutes and not affecting coastal scutes; smaller than 15 cm long. Maybe caused by beaten with rocks during nesting process or very old injuries produced during juvenile stage.
- *Undeterminated*: when specifications on the datasheet are not enough to identify the injury.

2. **FLIPPER LESIONS**: flipper amputations, generally caused by entanglement; where it was established a division into front and rear flippers, because they do not have the same function and the injury will affect the animal in different ways (Fig. 14).

- *Front flipper injuries:*
  - 1 partial front flipper amputation
  - 2 partial front flipper amputation
  - 1 total front flipper amputation
  - 2 total front flipper amputation
  - 1 partial and 1 total front flipper amputation
- *Rear flipper injuries:*
  - 1 partial rear flipper amputation
  - 2 partial rear flipper amputation
  - 1 total rear flipper amputation
  - 2 total rear flipper amputation
  - 1 partial and 1 total rear flipper amputation

Partial amputation is considered when only half of the flipper has been lost, and Total amputation, when the amputation reaches the humerus of the animal, leaving less than 5cm of the flipper.

We were also carry out a study to see if the turtles that present total or partial amputations in hind flippers achieve the nesting success, observing if they are able to dig the incubation chamber.

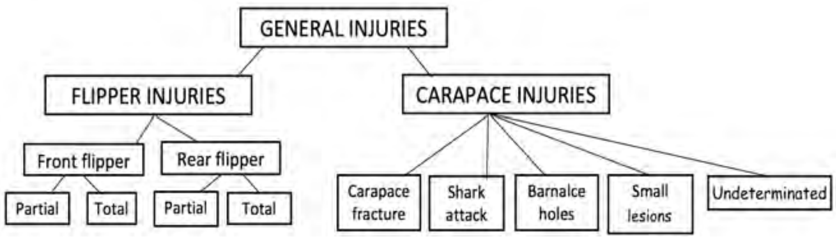


Figure 14. Injuries classification.

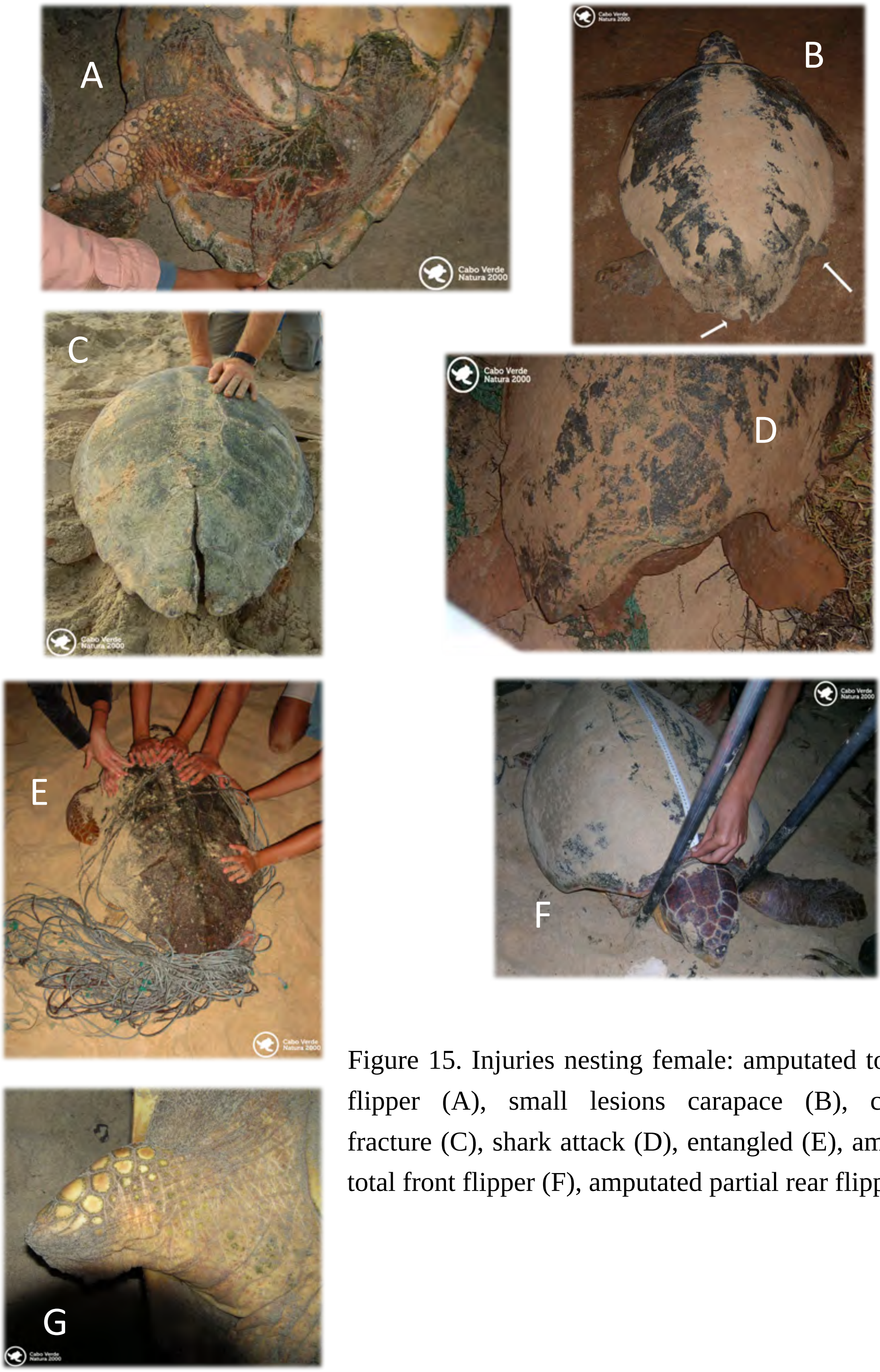


Figure 15. Injuries nesting female: amputated total rear flipper (A), small lesions carapace (B), carapace fracture (C), shark attack (D), entangled (E), amputated total front flipper (F), amputated partial rear flipper (G).

3. RESULTS

3.1 FREQUENCY OF INJURED TURTLES ALONG THE TIME:

In table 2 and figure 16 are shown the temporal distribution of injured and non-injured turtles observed in the studying area along the 10 years analysed.

Year	Total turtles analyzed	Turtles without injuries		Turtles with injuries					
				Total		Carapace lesions		Flipper lesions	
	N	*n*	*Freq (%)*	*n*	*Freq (%)*	*n*	*Freq (%)*	*n*	*Freq (%)*
2005	1727	1141	(66,07%)	586	(33,93%)	188	(10,89%)	398	(23,05%)
2006	1167	861	(77,78%)	306	(26,22%)	101	(8,65%)	205	(17,57%)
2007	1041	750	(72,05%)	291	(27,95%)	119	(11,43%)	172	(16,52%)
2008	672	537	(79,92%)	135	(20,09%)	37	(5,51%)	98	(14,58%)
2009	774	551	(71,19%)	223	(28,88%)	57	(7,36%)	166	(21,45%)
2010	840	592	(70,48%)	248	(29,52%)	101	(12,02%)	147	(17,50%)
2011	687	490	(71,32%)	197	(28,67%)	82	(11,94%)	115	(16,74%)
2012	1566	1333	(85,12%)	233	(14,87%)	56	(3,58%)	177	(11,30%)
2013	1122	900	(80,21%)	222	(19,78%)	96	(8,56%)	126	(11,23%)
2014	856	702	(82,01%)	154	(17,99%)	82	(9,58%)	72	(8,41%)
2015	639	519	(81,22%)	120	(18,77%)	50	(7,82%)	70	(10,95%)
Average	*1008*	*761*	*(75,76%)*	*247*	*(24,24%)*	*88*	*(8,85%)*	*159*	*(15,39%)*

Table 2. Table of frequencies of turtles injured by years.

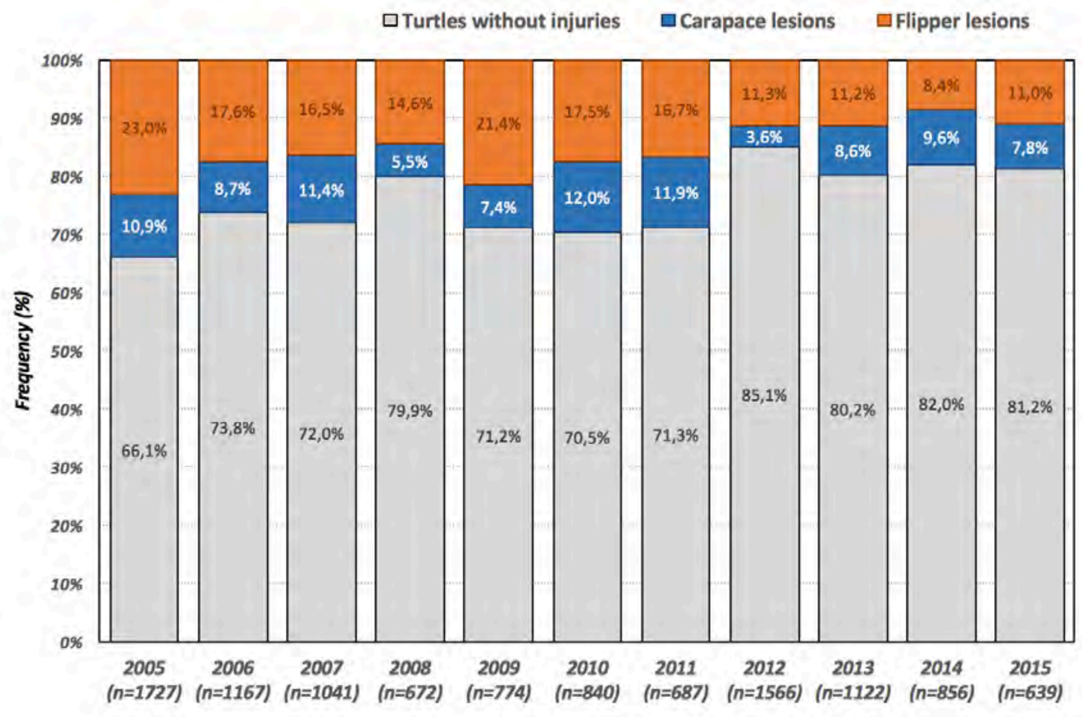


Figure 16. Frequency histogram of turtles affected by main injuries.

In general, almost the 25% of nesting females observed in Boa Vista beaches presents some kind of injury, in different degrees.

The first year present the highest frequency of injured turtles (33.93%) because collect injured turtles from all previous years (each individual was included only the first time that there was observed in the beach).

Carapace lesions were founded in about 8-10% of the turtles studied each year, except in 2007, 2010 and 2011 (11.43%, 12.02%, 11.54% respectively) where frequency was slightly higher, and 2008 (5.51%) y 2012 (3.58%) where frequency was really low. Frequency of turtles with flipper injuries was always higher than the ones with carapace lesions, and was observed in about 15-16% of the turtles each year. Only higher values were observed in 2005 (23.05%) and 2009 (21.45%), and lower values were founded in the last four years, 2012 (11.30%), 2013 (11.23%), 2014 (8.41%) and 2015 (11.95%).

3.2 CARAPACE INJURIES:

Year	Turtles with carapace injuries	Carap. fracture	Shark attacks	Barnacle holes	Small carap. lesion	Undet. carap. lesion
	N	*n Freq (%)*	*n Freq (%)*	*n Freq (%)*	*n Freq (%)*	*n Freq (%)*
2005	188	6 (3,19%)	14 (7,45%)	15 (7,98%)	60 (31,91%)	93 (49,47%)
2006	101	2 (1,98%)	6 (5,94%)	12 (11,88%)	57 (56,44%)	24 (23,76%)
2007	119	0 (0,00%)	2 (1,68%)	21 (17,65%)	66 (55,46%)	30 (25,21%)
2008	37	6 (16,22%)	1 (2,70%)	7 (18,92%)	20 (54,05%)	3 (8,11%)
2009	57	5 (8,77%)	3 (5,26%)	7 (12,28%)	40 (70,18%)	2 (3,51%)
2010	101	13 (12,87%)	12 (11,88%)	13 (12,87%)	50 (49,50%)	13 (12,87%)
2011	82	3 (3,66%)	6 (7,32%)	17 (20,73%)	54 (65,85%)	2 (2,44%)
2012	56	4 (7,14%)	3 (5,36%)	9 (16,07%)	39 (61,64%)	1 (1,79%)
2013	96	8 (8,33%)	1 (1,04%)	19 (19,79%)	59 (61,46%)	9 (9,38%)
2014	82	6 (7,32%)	2 (2,44%)	14 (17,07%)	51 (62,20%)	9 (10,98%)
2015	50	0 (0,00%)	7 (14,00%)	8 (16,00%)	34 (68,00%)	1 (2,00%)
Average	*88*	*5 (6,32%)*	*5 (5,92%)*	*13 (15,57%)*	*48 (58,61%)*	*17 (13,59%)*

Table 3. Frequencies of turtles affected by different carapace injuries along the years.

During the first 3 years of data recording, but mainly the first one, there was observed high percentages of “Undetermined carapace injuries” (49.47%, 23.76% and 25.21% respectively) (Table 3), probably due to lack of staff experience in collecting this kind of data.

In general, the most frequent injury observed in relation with carapace was the “Small carapace lesions”, hovering around the 60-65% of the turtles with carapace lesions (not counting the first 3 years), although the higher percentages were observed in 2009 (70.18%) and the lower in 2010 (49.50%) (Fig. 17).

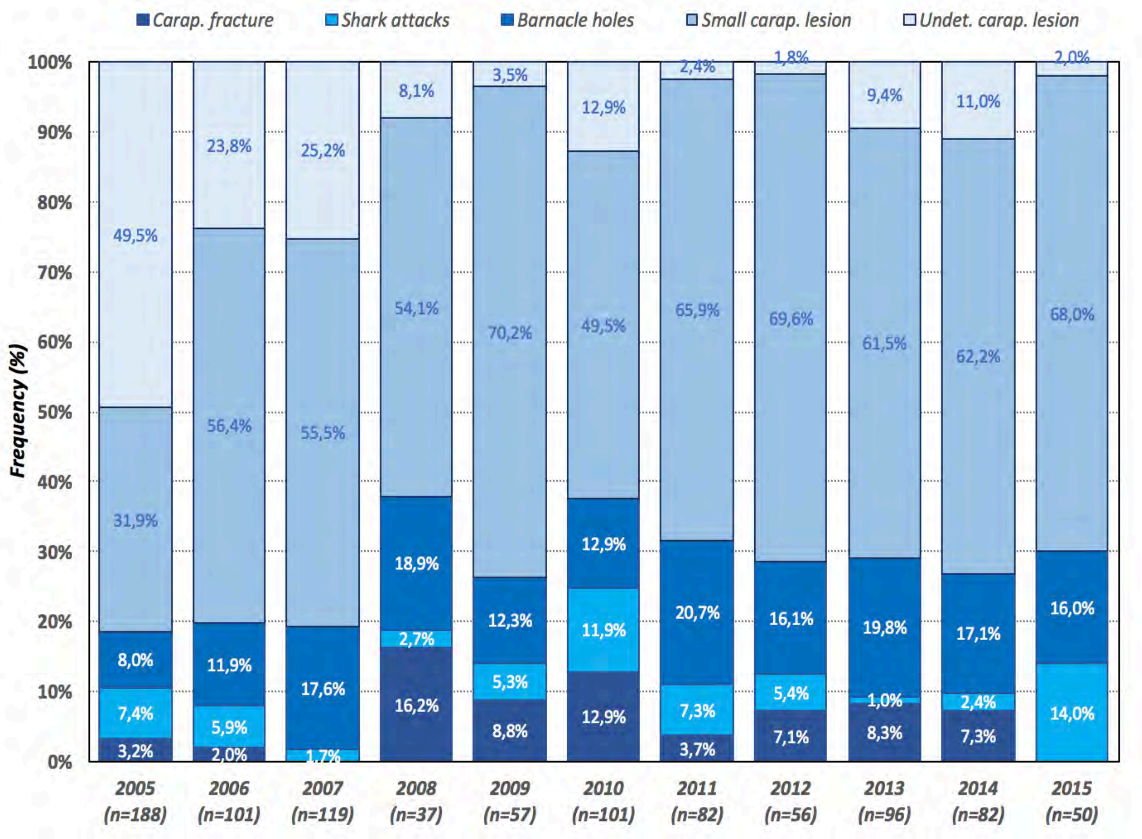


Figure 17. Frecuency histogram of turtles affected by carapace injuries.

“Barnacle holes” was observed in the 15% of the turtles with carapace lesions, with a higher frequency in 2011 (20.73%) and lower in 2009 (12.28%) (first 3 years not counted) (Fig.17).

“Shark attack” and “Carapace fracture” were the least frequent lesions observed and showed important variations among the years. In carapace fractures, higher frequency was founded in 2008 (16.2%) and the lower in 2011 (3.66%). Shark attack was more frequent in 2015 (14.00%) and in 2013 was founded only one case (1.04%) (Fig.17).

3.3 FLIPPER INJURIES:

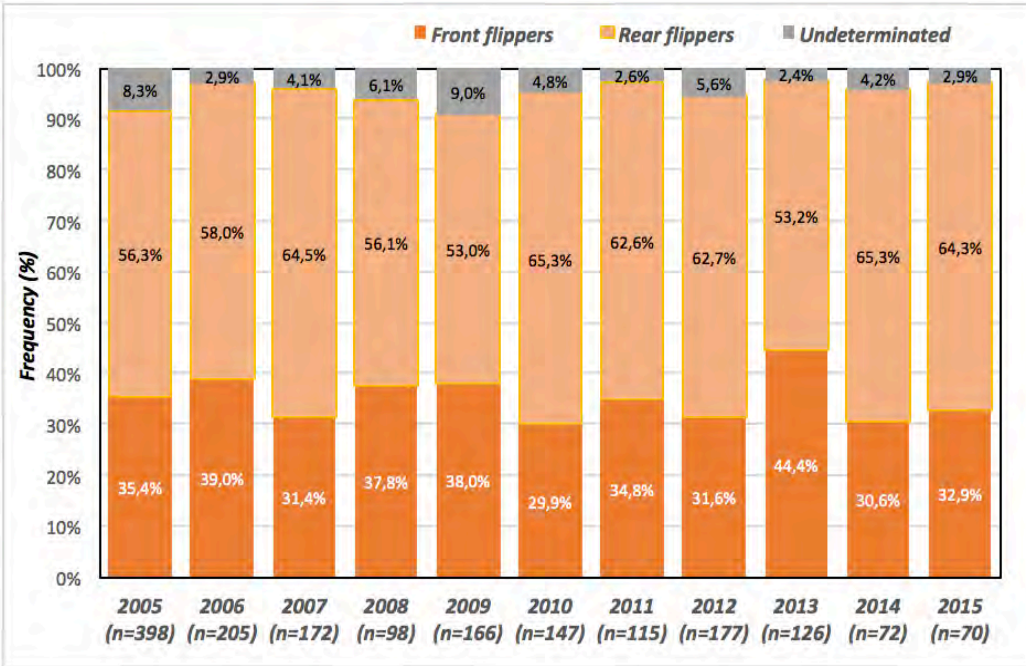


Figure 18. Frequency histogram of turtles affected by flipper injuries along the years.

Turtles with lesions in the rear flippers are more frequent (60.12%) than the ones with front flippers lesions (34.00%), even if both are fairly stable over the years (Figs. 18 and 19).

Looking at the frequency of turtles with different kinds of flipper lesions, no turtles were founded with two front flippers amputation, both total amputations or one total and one partial. The same lesion in the rear flippers almost has not been observed (1% and 2% respectively). One partial amputation was the most frequent lesion observed (73% of turtles with rear flipper lesions and 93% in the ones with front flipper lesions). Turtles with one total amputation were more frequent in rear flippers (19%) than front flippers (4%), and double partial amputation was low in both cases (5% in rear flippers and 3% in front flippers) (Fig. 19).

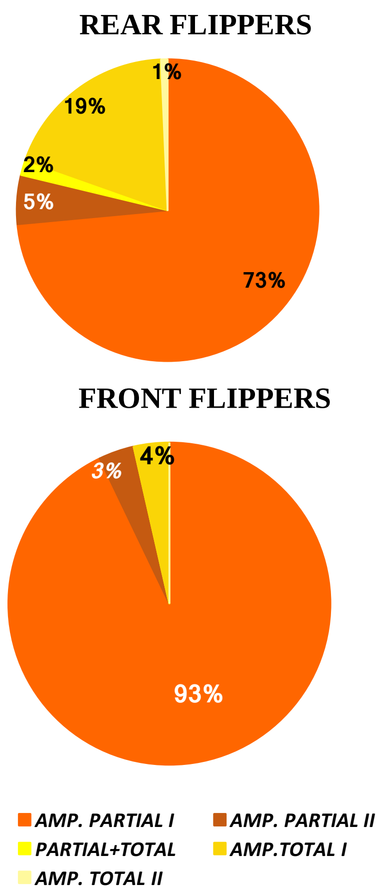


Figure 19. Frequency of main rear and front flippers lesions.

3.4 SPATIAL DISTRIBUTION:

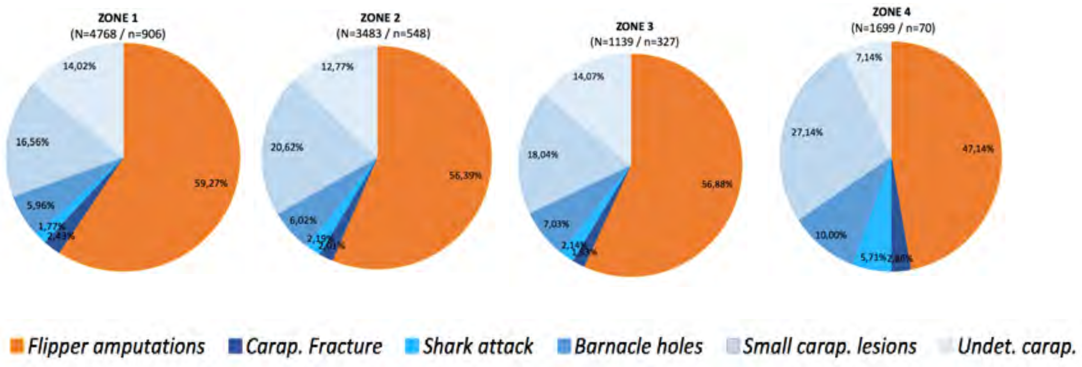


Figure 20. Frequency of turtles with different kind of injuries observed along the studying zones.

Turtles founded in the *Reserva Natural das Tartarugas* (Zone 1, Zone 2 and Zone 3), presented almost similar frequencies on their lesions (Fig. 20). The greater part (55-60%) presented flipper lesions, followed by "small carapace lesions" (16-20%) and "barnacle holes" (6-7%). "Carapace lesions" and "shark attack" were observed in a small number of turtles (around 2% each one). The Zone 4, included in the *Parque Natural do Norte* (PNN), presented lower number of turtles injured than the other zones. Besides, showed a lower frequency of flipper lesions (47.1%), higher frequencies of "small carapace lesions" (27.1%) and "shark attacks" (5.7%), and slightly high "barnacles holes" (10%) and "carapace fractures" (2.9%) (Fig.20).

3.5 CARAPACE LENGTH (LCCmin):

There are no important differences in carapace length of turtles affected by different lesions (Fig. 21). The great part of the turtles fit in the LCC range of Cape Verde loggerhead colony. Only the turtles affected by "small carapace lesions" are slightly smaller (79.50cm LCCmin average) and turtles with "flipper lesions" are slightly larger (82.23cm LCC average) than the turtles affected by other lesions (Fig. 21).
Is important to consider that some injuries prevent to collect biometric data, so few turtles affected by "carapace fracture" and "shark attacks" could be included in this analysis (n=48 and n=25 respectively).

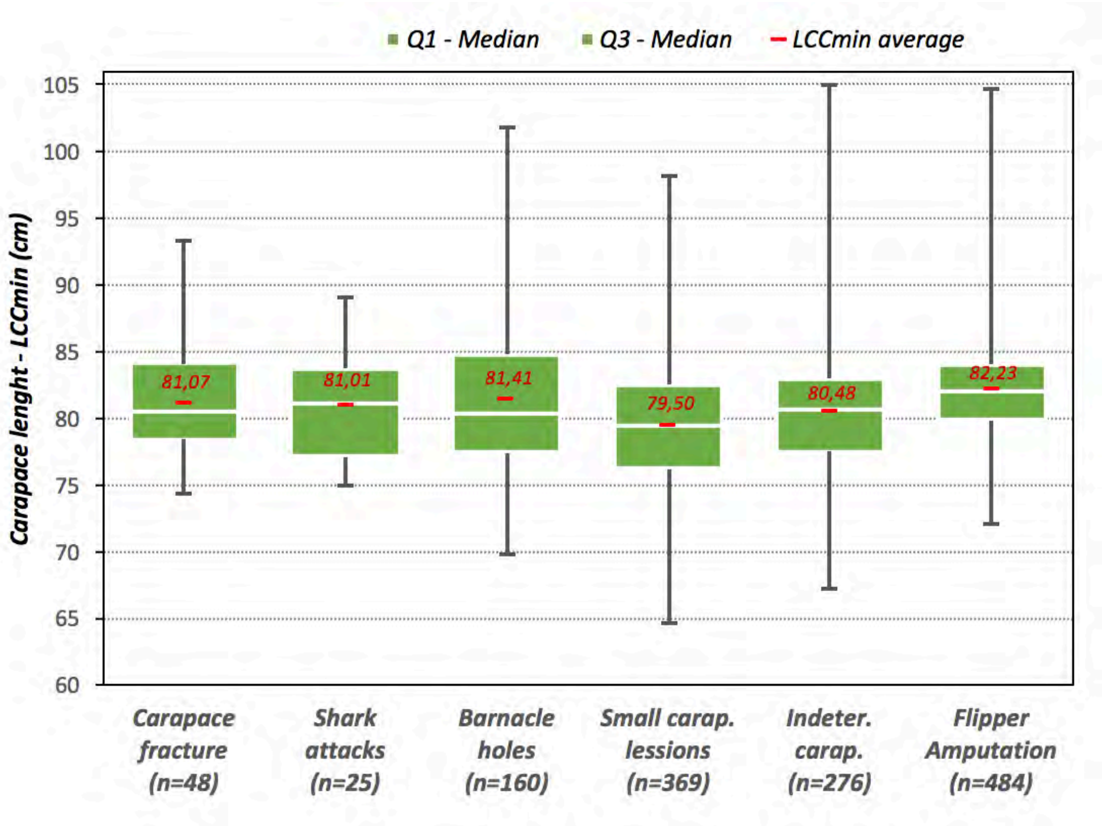


Figure 21. Boxplot of carapace length (LCCmin) by main king of lesions.

3.6 FLIPPER INJURIES AND NESTING SUCCESS

A long-term impact of the flipper injuries on turtle colonies is that rear flipper amputations can incapacitate turtles to dig the nest. Therefore, a specific study to analyse the nesting success of turtles affected by rear flipper injuries was developed.

In general, almost the 60% of turtles affected by rear flipper lesions are not able to achieve the nest successfully; therefore, these females are not productive for the colony (Fig. 22).

No turtle with total amputation of both hind flippers is capable of digging the nest and only the 25% of the turtles with both hind flippers affected, one of them partially amputated, achieve the nest successfully. Less than half of turtles with one flipper amputation, partially (41.5%) or total (38.7%), are able to dig the egg chamber. Finally, half of the turtles with both rear flippers partially amputated achieve the nest successfully (52.6%) (Fig. 22).

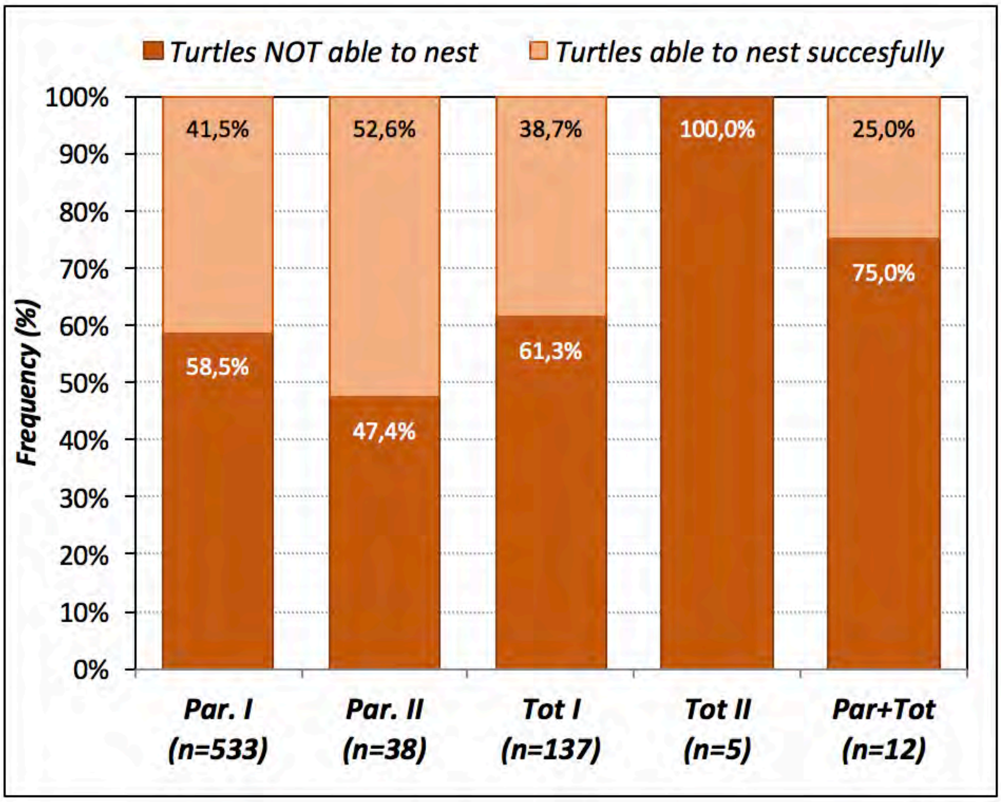


Figure 22. Frecuency of nesting successfully in turtles with amputations.

4. DISCUSSION:

The analysis of 11.090 nesting females from the Cape Verde loggerhead colony intercepted during the nesting process in two important Protected Areas (*Reserva Natural de Tartarugas* and *Parque Natural do Norte*) of Boa Vista Island (Cape Verde), indicate that about 25% of nesting females presents any kind of injury, in different degrees. (Orós *et al*., 2001).

First three years (2005-2007), have to be treated with caution due to the accumulation of individuals from several years prior to the study (39,93% of the turtles presented some kind of lesion in 2005), and the lack of experience of the NGO staff in the collection of this kind of data, clearly observed in the high percentages of undetermined carapace injuries (49.47%) in 2005.

Carapace injuries were observed in the 8.74% of turtles, where the most frequent was the small carapace lesions (58.61%) (Marco *et al*., 2012). This kind of lesion was considered as ancient injuries healed in the past that could be derived from: i) entanglements or injuries during juvenile stages, associated with females in their early reproductive years and close to their juvenile stage; ii) hits with rocks during precedent nesting process, identifying ancient females that have been reproducing for many years. The carapace length of females with this lesion are slightly lower (79.50cm LCC) than the rest of the turtles with other lesions, so, we consider this lesion associated with young females and their high frequency as an indicator of a young population with a high degree of new recruitments in the colony. This lesion was most frequent in 2009 (70.18% of turtles with carapace lesions) and lower in 2010 (49.50%).

The presence of barnacles in adult loggerhead turtles is linked with neritic habitat use (Liria-Loza pers. comm.), which is associated with larger and less numerous Cape Verde loggerhead females (Hawks *et al.*, 2006). This injury was observed in the 15.57% of the turtles affected by carapace lesions and presented lower frequencies in 2009 (12.28%), which correspond with the higher frequencies of young females with more small carapace lesions. In 2011 higher frequencies (20.73%) of this injury was observed, so, we consider that more ancient females and/or less young females were arrived to Boa Vista to nest.

Carapace fractures and shark attacks were present in lowest frequencies (6.32% and 5.92% respectively) and showed small variations among the years. Carapace fractures were most frequent in 2008 (16.2%) and less in 2011 (3.66%). Shark attack was more frequent in 2015 (14.00%) and in 2013 was founded only one case (1.04%).

In general, carapace lesion frequencies were slightly higher in 2007, 2010 and 2011 (11.43%, 12.02%, 11.54% respectively) associated with more presence of neritic females, and really low in 2008 (5.51%), 2009 (7.36%) and 2012 (3.58%), linked to the higher presence of young oceanic females.

In relation with flipper injuries, the frequency of turtles with this kind of lesion was always higher than the ones with carapace lesions (Wyneken *et al.*, 2008). It was observed in the 15.74% of turtles studied, where lesions in the rear flippers were twice as frequent (60.12%) as front flippers lesions (34.%). The viability of turtles with flipper amputations is still unknown, but this study observed that NO turtles with both front flippers amputated (both totally, or one totally and one partially) were present in the nesting areas, so they are no viable in the nature, or they do not achieve the reproductive migration. The same lesion in the rear flippers has been observed only in 1-2% of the turtles analysed.

It seems that one partial flipper amputation is the one that least affects the viability of females, because it was the most frequent lesion observed (73% of turtles with rear flipper lesions and 93% in the ones with front flipper lesions). Turtles with one total amputation were more frequent in rear flippers (19%) than front flippers (4%), and double partial amputation was low in both cases (5% in rear flippers and 3% in front flippers).

A long-term impact of the flipper injuries on turtle colonies is that rear flipper amputations can incapacitate turtles to dig the nest. The results shown that turtles with both hind flippers affected are almost not able to dig the nest and achieve the nest chamber successfully (0% of females with double total amputation and only 25% of females with one total and one partial amputation). Only the turtles with both rear flippers partially amputated are capable to achieve the nest successfully, but only the 52.6% of them and depending on the degree of partial amputation. Turtles with only one rear flipper injured are also affected, where less than half of turtles are able to dig the egg chamber (41.5% with one partial amputation and 38.7% with one total amputation) (Nelms *et al.*, 2016).
In general, almost the 60% of turtles affected by rear flipper lesions are not able to achieve the nest successfully, so there are not productive for the colony.

In relation with spatial distribution, there have not been observed important differences between zones. The zone 4, included in the PNN Protected Area, presented lower numbers of injured turtles (only 70 from 1699 turtles observed), mainly turtles with flipper lesions (47.1% instead of the 58-60% observed in the other zones), perhaps due to oceanographic and geographic conditions of the area, characterized by a steep coast, greater beach slopes and more exposed to predominant currents. Turtles with flipper injuries find greater problems to achieve the coast and the beaches in this area, instead of the RNT beaches where more extensive, less sloped and softer current areas are located, due to the own island protection (Varo-Cruz, 2010).

The relation with carapace length there has not been observed important differences, instead of the small size of turtles affected by small carapace lesions. In general, the different lesions analysed in the study affect all size turtles, but important differences in the number of cases for each lesion could be disturbing the analysis. For example, some injuries prevent to collect biometric data; so, few turtles affected by “carapace fracture” and “shark attacks” could be included in this analysis.

CONCLUSION

- The 25 % of nesting females present some kind of lesion, but with different degrees.

- In carapace injuries, were observed the small carapace lesions as the most common among turtles analyzed that could be derived from entanglements or injuries during juvenile stages, and hits with rocks during precedent nesting process.

- The highest percentages of barnacles holes in adult loggerhead carapace is linked with neritic hábitat, which is associated with larger colony females.

- Carapace lesions frequencies were higher in 2007, 2010 and 2011, associated with neritic females, and carapace lesions frequencies were smaller in 2008, 2009 and 2012, linked to higher presence of young oceanic females.

- Flipper amputations frequencies are higher than carapace injuries along the years. And the rear amputations more common than front amputations.

- Results observed that turtles with total front flipper amputated (both totally, or one totally and partially) are no able viable in the nature.

- Almost the 60% of turtles affected by rear flipper lesions are not able to achieve the nest successfully, so there arenot productive for the colony.

- In relation with spatial distribution, there have not been observed important differences between zones. The zone 4, presented lower numbers of injured turtles, that could be derived from the oceanographic and geographic conditions of the área, which entail to the turtles found problems arriving to the beaches.

The relation with carapace length there has not been observed important differences, instead of the small size of turtles affected by small carapace lesions. So that, the differences injuries analyzed in the study affect all size turtle.

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REFERENCES

Bowen, B., Avise, J. C., Richardson, J. I., Meylan, A. B., Margaritoulis, D., & Hopkins-Murphy, S. R. (1993). Population structure of loggerhead turtles (*Caretta caretta*) in the northwestern Atlantic Ocean and Mediterranean Sea. *Conservation Biology*, *7*(4), 834-844.

Bolten, A. B. (2003). Variation in sea turtle life history patterns: neritic vs. oceanic developmental stages. *The biology of sea turtles*, *2*, 243-257.

Bolten, A. B., & Witherington, B. E. (Eds.). (2004). Loggerhead Sea Turtles. *Marine Turtle Newsletter*, *104: 1-* 319pp.

Bjorndal, K.A. (1997). Foraging Ecology and Nutrition of Sea Turtles. 199-232. In: Lutz, P. & Musick, J. (eds.), The biology of sea turtles. CRC Press. Boca Raton (Florida), USA Varo Cruz, N..

Camacho, M., Luzardo, O. P., Boada, L. D., Jurado, L. F. L., Medina, M., Zumbado, M., & Orós, J. (2013). Potential adverse health effects of persistent organic pollutants on sea turtles: evidences from a cross-sectional study on Cape Verde loggerhead sea turtles. *Science of the total environment*, *458*: 283-289.

Carreras, C., Cardona, L., & Aguilar, A. (2004). Incidental catch of the loggerhead turtle *Caretta caretta* off the Balearic Islands (western Mediterranean). *Biological Conservation*, *117*(3): 321-329.

Casale, P., Riskas, K., Tucker, A. D., & Hamann, M. (2015). Caretta caretta (south east Indian Ocean subpopulation). The IUCN Red List of Threatened Species 2015: e. T84189617A84189662.

Crespo-Picazo, J. L., Martínez, V., Martins, S., Abella, E., López, P., García-Párraga, D., & Marco, A. (2013). Surgical repair of a large shell injury in a loggerhead sea turtle Caretta caretta and the need for a wildlife recovery centre in the Cape Verde Islands. *Zoología Caboverdiana*.

Eckert, K. L., Bjorndal, K. A., Abreu-Grobois, F. A., & Donnelly, M. (2000). Introducción a la evolución, historias de vida y biología de las tortugas marinas. *Técnicas de Investigación y Manejo para la Conservación de las Tortugas Marinas*, 3.

Eder, E., Ceballos, A., Martins, S., Pérez-García, H., Marín, I., Marco, A., & Cardona, L. (2012). Foraging dichotomy in loggerhead sea turtles *Caretta caretta* off northwestern Africa. *Marine Ecology Progress Series*, *470*: 113-122.

Gilman, E., Zollett, E., Beverly, S., Nakano, H., Davis, K., Shiode, D., ... & Kinan, I. (2006). Reducing sea turtle by-catch in pelagic longline fisheries. *Fish and Fisheries*, *7*(1): 2-23.

Gramentz, D. (1988). Involvement of loggerhead turtle with the plastic, metal, and hydrocarbon pollution in the central Mediterranean. *Marine Pollution Bulletin*, *19*(1): 11-13.

Hawkes, L. A., Broderick, A. C., Coyne, M. S., Godfrey, M. H., Lopez-Jurado, L. F., Lopez-Suarez, P., ... & Godley, B. J. (2006). Phenotypically linked dichotomy in sea turtle foraging requires multiple conservation approaches. *Current Biology*, *16*(10): 990-995.

Hamann, M., Godfrey, M. H., Seminoff, J. A., Arthur, K., Barata, P. C. R., Bjorndal, K. A., ... & Casale, P. (2010). Global research priorities for sea turtles: informing management and conservation in the 21st century. *Endangered Species Research*, *11*(3): 245-269.

Hamann, M., Limpus, C. J., & Owens, D. W. (2003). Reproductive cycles of males and females. *The biology of sea turtles*, *2*: 135-161.

Hazel, J., Lawler, I. R., Marsh, H., & Robson, S. (2007). Vessel speed increases collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research*, *3*: 105-113.

Heithaus, M. R. (2001). The biology of tiger sharks, Galeocerdo cuvier, in Shark Bay, Western Australia: sex ratio, size distribution, diet, and seasonal changes in catch rates. *Environmental Biology of Fishes*, *61*(1): 25-36.

Ivar do Sul, J. A., Santos, I. R., Friedrich, A. C., Matthiensen, A., & Fillmann, G. (2011). Plastic pollution at a sea turtle conservation area in NE Brazil: contrasting developed and undeveloped beaches. *Estuaries and Coasts*, *34*(4): 814-823.

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., ... & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, *347*(6223): 768-771.

Lewison, R. L., Freeman, S. A., & Crowder, L. B. (2004). Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback sea turtles. *Ecology letters*, *7*(3): 221-231.

Lewison, R. L., & Crowder, L. B. (2007). Putting longline bycatch of sea turtles into perspective. *Conservation Biology*, *21*(1): 79-86.

Limpus, C. J., Miller, J. D., Paramenter, C. J., Reimer, D., McLachlan, N., & Webb, R. (1992). Migration of green (Chelonia mydas) and loggerhead (Caretta caretta) turtles to and from eastern Australian rookeries. *Wildlife Research*, *19*(3): 347-357.

López-Jurado, L. F., Cabrera, I., Cejudo, D., Évora, C., & Alfama, P. (2002). Distribution of marine turtles in the archipelago of Cabo Verde, western Africa.

Lutz, P. L., Musick, J. A., & Wyneken, J. (Eds.). (2002). *The biology of sea turtles* (Vol. 2). CRC press.

Lutz, P. L., Musick, J. A., & Wyneken, J. (2003). The biology of sea turtles, Volume II. *Marine Turtle Newsletter*, *102:1*- 455pp.

Marcovaldi, M. Â., Godfrey, M. H., & Mrosovsky, N. (1997). Estimating sex ratios of loggerhead turtles in Brazil from pivotal incubation durations. *Canadian Journal of Zoology*, *75*(5): 755-770.

Margaritoulis, D., Argano, R., Baran, I., Bentivegna, F., Bradai, M. N., Camiñas, J. A., ... & Godley, B. J. (2003). Loggerhead turtles in the Mediterranean: present knowledge and conservation perspectives. *Loggerhead Sea Turtles (editors: AB Bolten and BE Witherington). Smithsonian Institution Press, Washington, DC, USA*, 175-198.

Miller, J. D., Limpus, C. J., & Godfrey, M. H. (2003). Nest site selection, oviposition, eggs, development, hatching, and emergence of loggerhead turtles. *Loggerhead sea turtles*, *12*.

Monzón-Argüello, C., Rico, C., Carreras, C., Calabuig, P., Marco, A., & López-Jurado, L. F. (2009). Variation in spatial distribution of juvenile loggerhead turtles in the eastern Atlantic and western Mediterranean Sea. *Journal of Experimental Marine Biology and Ecology*, *373*(2): 79-86.

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.

Mrosovsky, N., Kamel, S., Rees, A. F., & Margaritoulis, D. (2002). Pivotal temperature for loggerhead turtles (Caretta caretta) from Kyparissia Bay, Greece. *Canadian Journal of Zoology*, *80*(12): 2118-2124.

Nelms, S. E., Duncan, E. M., Broderick, A. C., Galloway, T. S., Godfrey, M. H., Hamann, M., ... & Godley, B. J. (2015). Plastic and marine turtles: a review and call for research. *ICES Journal of Marine Science*, *73*(2): 165-181.

Nelms, S. E., Piniak, W. E., Weir, C. R., & Godley, B. J. (2016). Seismic surveys and marine turtles: An underestimated global threat. *Biological conservation*, *193*: 49-65.

Orós, J., Torrent, A., Calabuig, P., & Déniz, S. (2005). Diseases and causes of mortality among sea turtles stranded in the Canary Islands, Spain (1998–2001). *Diseases of aquatic organisms*, *63*(1): 13-24.

Orós, J., Montesdeoca, N., Camacho, M., Arencibia, A., & Calabuig, P. (2016). Causes of Stranding and Mortality, and Final Disposition of Loggerhead Sea Turtles (Caretta caretta) Admitted to a Wildlife Rehabilitation Center in Gran Canaria Island, Spain (1998-2014): A Long-Term Retrospective Study. *PloS one*, *11*(2), e0149398.

Perrault, J. R., Miller, D. L., Garner, J., & Wyneken, J. (2013). Mercury and selenium concentrations in leatherback sea turtles (Dermochelys coriacea): population comparisons, implications for reproductive success, hazard quotients and directions for future research. *Science of the Total Environment*, *463*: 61-71.

Renous, S., de Broin, F. D. L., Depecker, M., Davenport, J., & Bels, V. (2008). Evolution of locomotion in aquatic turtles. *Biology of Turtle. From Structures to Strategies of Life*, 97-138.

Ryan, P. G., Cole, G., Spiby, K., Nel, R., Osborne, A., & Perold, V. (2016). Impacts of plastic ingestion on post-hatchling loggerhead turtles off South Africa. *Marine Pollution Bulletin*, *107*(1): 155-160.

Stewart, K. R., & Wyneken, J. (2004). Predation risk to loggerhead hatchlings at a high-density nesting beach in southeast Florida. *Bulletin of Marine Science*, *74*(2): 325-335.

Tomás, J., Gozalbes, P., Raga, J. A., & Godley, B. J. (2008). Bycatch of loggerhead sea turtles: insights from 14 years of stranding data. *Endangered Species Research*, *5*(2-3): 161-169.

Tomás, J., Guitart, R., Mateo, R., & Raga, J. A. (2002). Marine debris ingestion in loggerhead sea turtles, Caretta caretta, from the Western Mediterranean. *Marine Pollution Bulletin*, *44*(3): 211-216.

Varo Cruz, N. (2010). Biología reproductora de la tortuga boba (Caretta caretta Linneo, 1758) en la isla de Boavista, archipiélago de Cabo Verde.

Varo Cruz, N., Loza, A. L., López López, O. A., & López Jurado, L. F. (2006). Manual para trabajos prácticos con tortugas marinas nidificantes en Cabo Verde.

Wallace, B. P., DiMatteo, A. D., Bolten, A. B., Chaloupka, M. Y., Hutchinson, B. J., Abreu-Grobois, F. A., & Bourjea, J. (2011). Global conservation priorities for marine turtles. *PloS one*, *6*(9), e24510.

Watson, J. W., Epperly, S. P., Shah, A. K., & Foster, D. G. (2005). Fishing methods to reduce sea turtle mortality associated with pelagic longlines. *Canadian Journal of Fisheries and Aquatic Sciences*, *62*(5): 965-981.

Witzell, W. N. (1987). Selective predation on large cheloniid sea turtles by tiger sharks (Galeocerdo cuvier). *Japanese Journal of Herpetology*, *12*(1): 22-29.

Work, P. A., Sapp, A. L., Scott, D. W., & Dodd, M. G. (2010). Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. *Journal of Experimental Marine Biology and Ecology*, *393*(1): 168-175.

Wyneken, J., Madrak, S. V., Salmon, M., & Foote, J. (2008). Migratory activity by hatchling loggerhead sea turtles (Caretta caretta L.): evidence for divergence between nesting groups. *Marine biology*, *156*(2): 171-178.

Wyneken, J. (2003). The Biology of Sea Turtles Volume II.

Descripción detallada de las actividades desarrolladas durante la realización del TFT.

Estudio completo e información detallada acerca del ciclo de vida de la especie de tortuga marina, *Caretta caretta.* Analizar los datos recopilados a lo largo de 17 años por la ONG Cabo Verde Natura 2000, que han llevado a cabo actividades de conservación y protección de la biodiversidad en Boa Vista, y así poder estudiar de manera más minuciosa el trabajo llevado a cabo, con la ayuda de programas como Excel con quien se ha ido estructurando los datos y organizando los datos en función de los años de estudio, y de las diferentes zonas donde las tortugas salen a nidificar. Estudio íntegro de la diversidad de lesiones que pueden afectar a la población de tortugas marinasm y de cómo pueden afectar en menor y mayor grado con la ayuda de artículos científicos y libros, y poder clasificarlas en la base de datos.

Formación recibida (cursos, programas informáticos, etc.)

La formación recibida durante todo este tiempo va relacionada directamente con las tareas llevadas a cabo, con la ayuda a su vez de información sacada de libros que me han sido proporcionados, con los programas informáticos empleados como excel, Word, pdf e incluso algunos extras como fue el empleo del Global Fishing Watch. Que es una herramienta de aprendizaje importante en la gestión de buques pesqueros, ya que permite determinar las zonas explotadas de manera exacta y sencilla al seguir un barco, su punto de partida y su ruta completa.

Nivel de integración e implicación dentro del departamento y relaciones con el personal.

Las relaciones que se establecieron con el resto del personal fueron muy buenas, debido al trabajo grupal llevado a cabo. Con el tutor, e incluso a la hora de empatizar con el resto de personal cuando se presentó algún problema y así poder solucionarlo entre todos. La implicación dentro del departamento fue completa, teniendo acceso directo al despacho para recopilar información siempre que fuera necesario.

Aspectos positivos y negativos más significativos relacionados con el desarrollo del TFT.

Entre los aspectos positivos que encontramos a lo largo del desarrollo del TFT, podemos señalar todos los conocimientos que he adquirido de la disciplina referente al mundo animal marino, en concreto las tortugas marinas. El buen ambiente de trabajo que hemos logrado crear entre todos y la maravillosa experiencia de trabajar con un animal tan agradecido y afable como es la tortuga boba *Caretta caretta.* Alguno de los aspectos menos positivos que podemos destacar serían las horas de dedicación con respecto al trabajo delante de un ordenador.

Valoración personal del aprendizaje conseguido a lo largo del TFT.

En mi opinión, el aprendizaje conseguido a lo largo de estos meses de trabajo en la empresa ha sido satisfactorio. Si bien he de señalar que gran parte de los mismos ya los había adquirido durante mi voluntariado trabajando con la misma especie de tortuga, al poder intervenir directamente con el animal en su estado más natural y salvaje y participar en cada uno de los momentos que cobran mayor importancia como son la salida del mar, la puesta y la eclosión posterior de los huevos, conduciendo a las crías de nuevo al mar. Con lo cual, y además de lo ya descrito anteriormente, creo que se necesitan unos conocimientos previos cuya facultad es quien los imparte, para despoés poder desarrollarlos por completo en cualquiera de los ámbitos que se nos plantean. Asñu como los conocimientos con respecto a los programas informáticos y estadísticos fueron aprendidos durante los años de universidad, que también han sido impartidos en diferentes asignaturas a lo largo del grado.