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# SEA TURTLE STRANDINGS (2010-2019) ALONG A SEMIARID COAST IN THE WESTERN EQUATORIAL ATLANTIC

FORTALEZA
2020

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Monografia apresentada ao Curso de Ciências Biológicas, do Departamento de Biologia, da Universidade Federal do Ceará, como requisito parcial para obtenção do título de Bacharel em Ciências Biológicas.

Orientador: Prof. Dr. Vicente Vieira Faria.

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A todos os cientistas que trazem a
luz em tempos de caos.

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## RESUMO

Cinco espécies de tartarugas marinhas ocorrem ao largo do Brasil e, apesar do crescente número de articulações para a preservação desses animais, todas as cinco estão ameaçadas de extinção. Dentre as abordagens de estudo desses animais está o Programa de Monitoramento de Praia (PMP). Amplamente usado devido aos seus benefícios, baixo custo e manutenção, um PMP pode trazer informações significativas a longo prazo sobre as tartarugas marinhas. No Ceará, os encalhes de tartarugas marinhas é pouco documentado, restrito a partes da costa do estado. Nesse contexto, conduzindo o PMP no litoral leste do estado, em um percurso de 130 km, por dez anos (2010 – 2019) foi possível entender aspectos das populações que utilizam o litoral do Ceará. Existe uma prevalência no número de encalhes da espécie *Chelonia mydas*, bem como a presença de três outras espécies. A maioria dos espécimes é juvenil, com encalhes que não seguem um padrão sazonal. Ainda, existe evidência de interação antropogênica, além da presença ocasional fibropapilomas nos animais.

**Palavras-chave**: Quelônios, Juvenis, Nordeste do Brasil, Ceará.

**ABSTRACT**

Five sea turtle species occur off Brazil and despite the increasing number of conservation measures taken, all five species are still considered endangered of extinction. Among many approaches used to study these animals there is Beach Monitoring Program (BMP). It is widely used due to its benefits, low cost and maintenance; BMP can provide valuable long-time information about sea turtles. In Ceará state, sea turtle strandings is poorly documented and restricted to a small portion of the state. In this context, through a BMP in the coastal area of the state, a route of 130 km approximately, for a decade (2010 – 2019) it was possible to understand more aspects of sea turtles populations that occur in this region. The majority of strandings are of *Chelonia mydas*, with the occurrence of three other species. Most of the turtles are juvenile and the strandings do not follow a seasonal pattern. In addition, anthropogenic interaction and fibropapillomatosis also occur.

**Key words**: Chelonian, Juveniles, Northeastern Brazil, Ceará.

**SUMMARY**

# 1. INTRODUCTION

Successful conservation programs are built on the largest range of knowledge about the aimed target and its major threats in order to set assertive conservation measures (FLINT, 2017; GODLEY, 2003). This background turns out a particular challenge for sea turtles considering that they spend most of their lives under water (GODLEY *et al.* 2020; MACHOVSKY-CAPUSKAA, ANDRADES & SANTOS, 2020). So even with long time efforts going on we still have a lack of information and therefore difficulties in following the full life cycle of turtles (GODLEY *et al.* 2020; GIBONS & LOVICH, 2019). All this framework of environmental difficulties and the biological ones, such as long migration periods, the late reproductive maturation and the low success of the offspring, make turtle conservation a hard and high importance case (GIBONS & LOVICH, 2019; POLI *et al.* 2014; MARCOVALDI *et al.* 2012)

Nowadays fishery, and indirectly bycatch, is considered one of the biggest threats for sea turtles decreasing populations significantly around the world (SNAPE *et al.* 2013). Another significant impact is caused by the amount of trash in the oceans. Also, there are diseases and disasters taking many animals too (POLI *et al.* 2014). In order to better understand these threats and acquire more information about sea turtles many projects search for different approaches of study. One of the easiest to apply is the beach monitoring.

Beach Monitoring Programs (BMPs) are widely used around the world and are a great way to improve data about sea turtle populations in a certain area (POLI *et al.* 2014). In Brazil this kind of survey as a long-time study can be sponsored by companies as a form of compensation for some polluting activities stipulated by law. For sea turtles BMPs may help to provide a set of information (POLI, *et al.* 2014), such as its threats, size of the local population, nesting incubation periods, anthropogenic interactions, spatial distribution, which species use the area and many other parameters that can be used to set priorities for conservation of these animals. BMPs are also commonly used for its low cost, once it can be done from land, with little personnel and simple tools are required. However, it is tied to the fact that all information can be considered an underestimated scenario of the real size of the issue (WALLACE *et al.* 2010; HART *et al.* 2005).

The Brazilian coastal zone and oceanic islands are well known habitats for sea turtles. These animals can be found there foraging, reproducing, or passing by through the migration corridors. Five species occur in the area: the green turtle (*Chelonia mydas*), the olive ridley turtle (*Lepidochelys olivacea*), the hawsbill turtle (*Eretmochelys imbricata*), the loggerhead turtle (*Caretta caretta*) and the leatherback turtle (*Dermochelys coriacea*). (MARCOVALDI & MARCOVALDI, 1999). Sea turtles have been nationally protected in Brazil since the 1980s with measures implemented by law alongside the work of projects such as the national TAMAR project (MARCOVALDI & MARCOVALDI, 1999) and many others acting locally. However, despite best efforts, up until now all five species are still included in both the Brazilian Red List of Threatened Species and the international Red List of IUCN (ICMBio/MMA, 2018; ABREU-GROBOIS & PLOTKIN, 2008; CASALE & TUCKER, 2017; MORTIMER & DONNELLY, 2008; SEMINOFF, 2004; WALLACE, TIWARI & GIRONDOT, 2013).

The occurrence of sea turtles along the coast Ceará state is a poorly documented issue, restricted mostly to one site of the west coast, but the whole coastal zone is already considered an important migration corridor and possible foraging ground (LIMA, MELO & FERREIRA, 2017; LIMA *et al.* 2013). Due to the importance of Ceará state for sea turtle populations and the need to set of conservation directions, the present study aimed i) to identify the species and the relatively abundance of sea turtle strandings alongside the coast, ii) to determine its maturation stage of these turtles, iii) to test if stranding patterns follow a temporal or geographical pattern, and iv) to characterize any sign of disease or anthropic interaction.

## 2. MATERIALS AND METHODS

### 2.1. Study area

Figure 1 - Beach survey route used for monitoring sea turtle strandings between 2010 and 2019 along a semiarid coast in the western equatorial Atlantic, eastern Ceará State (from Aquiraz to Aracati), northeastern Brazil. Each interval in the scale represents 5km linear distance.


Figure 2 – Map of Brazil showing the location of Ceará state.


Source of the maps: Google Maps.

Ceará state is part of Northeastern Brazil in a region of semi-arid weather without the four-season system; the two main differentiation through the year happens to be rain/ wind. The first term concentrates almost 91% of the rain with low speed winds, while the second term has the opposite scenario (MORAIS *et al.* 2006). Its coastline has 573 km and suffers greatly from erosion from anthropogenic and natural causes. The state has its economy strongly associated with tourism, in 2019 during the first four months, it was the fifth capital of Brazil in number of international tourists.

Between February 2010 and July 2019, the Associação de Pesquisa e Preservação de Ecosistemas Aquáticos (NGO AQUASIS) conducted beach surveys in the coast of Ceará state through the Beach Monitoring Program (BMP). The route started from the east side of Pacoti River in Aquiraz-CE and ended in Aracati-CE (Fig. 01). The coastline route was approximately 130 km long. The monitoring team was composed of two people. A 4x4 pickup truck was used during surveys that usually took around 8 hours. The interval between surveys was 20 days, in average, varying from five to 17 surveys per year. During a survey, when a high tide precluded the route a ferry was used, or the team waited for the low tide to continue the survey. In cases where none of the options were available the team would resume the survey in the following day. Another alternative was the team being split part driving by the road while the remaining would walk the shore.

### 2.2. Specimens

The species identification followed (REIS & GOLDBERG, 2017). One character considered for species identification was number of costal scutes. Shape of scutes and nuances of color were used for confirmation of green and hawksbill turtles because they do not differ in the number of scutes. Animals without carapace (removed) or in advanced stage of decomposing were recorded as ‘not identified’; the head of the turtle was not used for identification. The curved carapace length (CCL) was measured with a flexible measurement tape. The CCL was taken from the mid-line of the nuchal notch to the tip of the supracaudals (BOLTEN, 1999). The date and geoposition were recorded. Evidence of disease and/or negative anthropic interaction were also recorded. Each animal was photographed.

### 2.3. Data analysis

The CCL was used to determine the maturation stage of each specimen. We used the smallest CCL found for nesting females in Brazil as a base. If the turtle found in the present study had a CCL smaller than the base it was considered juvenile. On the other hand, if the CCL was equal or larger than the base it was considered adult. The following CCL values were considered for adults: (1) *Chelonia mydas*, CCL ≥ 90 cm (ALMEIDA *et al.* 2011); (2) *Lepidochelys olivacea*, ≥ 65,3 cm (SILVA *et al.* 2007); (3) *Eretmochelys imbricata*, ≥ 83 cm (SANTOS *et al.* 2010); (4) *Caretta caretta*, ≥ 86,5 cm (LIMA *et al.* 2012).

The significance of the variation in number of strandings by year and season of the year was tested using Kruskal-Wallis and the post-hoc of multiple comparisons test (Statistica v. 10). This test was chosen after testing for the homocedascity (Barlett) and normality (Shapiro-Wilk) (Statistica v. 10). The Pearson correlation between coastline size and the number of strandings of each municipality was also determined (Excel). A chi-square was used to test for difference in species abundance (the number of stranded specimens).

## 3. RESULTS

A total of 905 stranded sea turtles belonging to four species were recorded. The most stranded species was *Chelonia mydas* (93%) ($p < 0,01$), followed by *Lepidochelys olivacea* (3%), *Eretmochelys imbricata* (2%), and *Caretta caretta* (0,6%). Another eight sea turtles recorded were not identified at the species level due to damaged carapace (Table 1).

Table 1 - Records of sea turtle strandings between 2010 and 2019 along a semiarid coast in the western equatorial Atlantic, eastern Ceará State, northeastern Brazil.

| | Species | | | | | |
|---|---|---|---|---|---|---|
| Year | *Chelonia mydas* | *Lepidochelys olivacea* | *Eretmochelys imbricata* | *Caretta caretta* | Not Identified | Total |
| 2010 | 106 | 1 | 1 | 0 | 7 | 115 |
| 2011 | 73 | 1 | 4 | 1 | 0 | 79 |
| 2012 | 92 | 3 | 3 | 0 | 0 | 98 |
| 2013 | 101 | 5 | 5 | 2 | 0 | 113 |
| 2014 | 111 | 7 | 4 | 1 | 0 | 123 |
| 2015 | 82 | 3 | 2 | 1 | 0 | 88 |
| 2016 | 93 | 3 | 0 | 0 | 0 | 96 |
| 2017 | 56 | 0 | 0 | 0 | 0 | 56 |
| 2018 | 71 | 5 | 2 | 0 | 0 | 78 |
| 2019 | 56 | 2 | 0 | 0 | 1 | 59 |
| Total | 841 | 30 | 21 | 5 | 8 | 905 |

The green turtle was the only species recorded along all years. The olive ridley turtle was recorded in nine years. The hawksbill turtle was recorded in seven years. Finally, the loggerhead turtle was recorded in four years (Table 1).

The number of stranded sea turtles in a single year varied between 56 and 123 (Table 1). Considering sampling effort per year and the number of strandings, overall, there is a significant variation through the years ($p < 0,05$). The highest abundance of strandings was recorded in 2010 and 2014, while the lowest was recorded in 2017 (Graphic 1), without any apparent pattern.

The relative strandings did not differ by season of the year ($p > 0,05$). The green turtle, the olive ridley turtle and the hawksbill turtle were recorded during all year (even though not every year). Loggerhead turtle was never recorded during three months in the first half of the year.

Sea turtle strandings within the study area were not associated to municipality/locality. The correlation between municipality coastline and number of strandings was r = 0,6187, which is considered a low correlation.

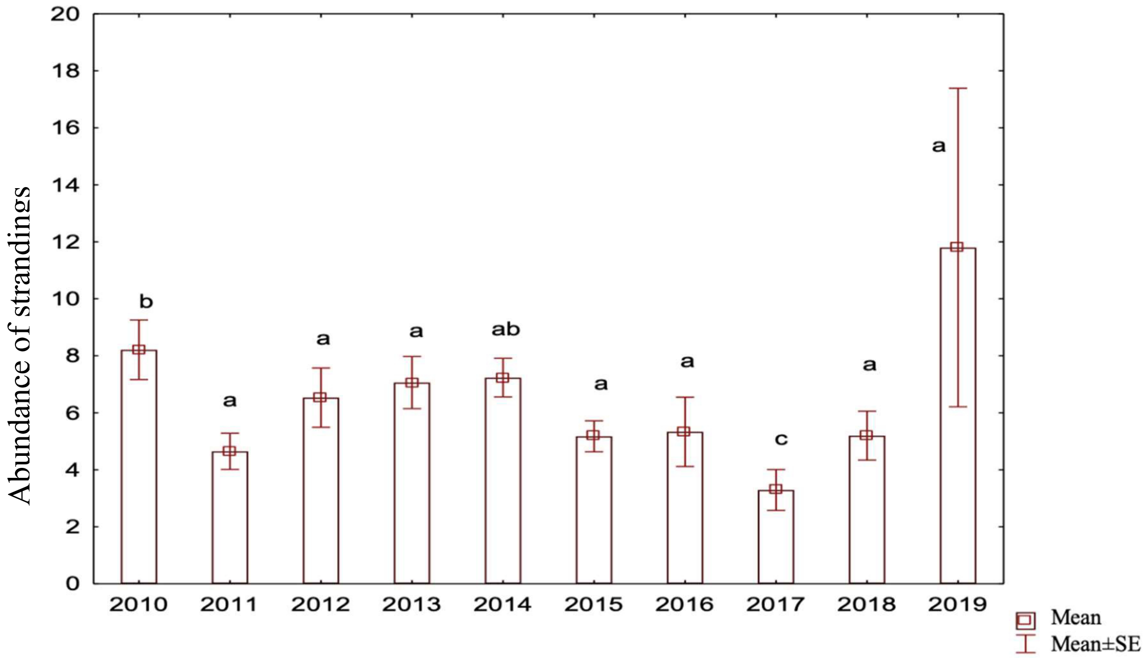
As for sea turtle life stage, based on curved carapace length (CCL) size, most specimens were juvenile green turtles. The hawksbill turtle was also mostly juvenile. On the other hand, the olive ridley and loggerhead turtles was mostly adults (Table 2).

Some stranded sea turtles showed evidence of fibropapillomatosis and/or negative anthropogenic interaction. The sick sea turtles had tumors (n = 17; 1,8%). The negative anthropic interactions (n = 37; 4%) included: entangled nets and ropes, trapped in lobster trap (manzuá), amputated flippers, sharp cuts (as if made by knife) (Appendix A).

Table 2 - Maturation stage and size of sea turtle strandings between 2010 and 2019 along a semiarid coast in the western equatorial Atlantic, eastern Ceará State, northeastern Brazil. CCL: curved carapace length. SD: standard deviation. *Four *Chelonia mydas* could not be measured due to damage in the carapace. **One *Eretmochelys imbricata* could not be measured due to damage in the carapace.

| Species | N | Juvenile | Adult | Min - Max CCL (cm) | Mean (SD) (cm) |
|---|---|---|---|---|---|
| *Chelonia mydas* | 841* | 730 | 107 | 27 - 126 | 60,2 (21,4) |
| *Lepidochelys olivacea* | 30 | 12 | 18 | 39 - 92 | 63,83 (8,64) |
| *Eretmochelys imbricata* | 21** | 17 | 3 | 34 - 100 | 55,94 (21,5) |
| *Caretta Caretta* | 5 | 1 | 4 | 47 - 107 | 88 (23,6) |

Graphic 1 – Frequency of strandings between 2010 and 2019 along a semiarid coast in western Atlantic. Different letters show statistical differences. ‘b’ and ‘ab’ are the highest frequency. ‘c’ is the lowest frequency.



# 4. DISCUSSION

This is the most extended study (a decade-length) on sea turtles strandings for the state of Ceará. In Ceará, the sea turtle has been mostly studied for western portion of the coast, but the present study fills in this gap bringing comprehensive information for the easternmost part of the State.

The conclusion that most stranded sea turtles in the region are juvenile green turtles, *Chelonia mydas*, is clearly supported by the number of records obtained. In order for a sea turtle to strand ashore, it usually dies close to shore because otherwise, if it happens in more deeper waters, it may simply decompose at-sea (HART *et al.* 2009). These authors estimate an approximate distance of 20 km from a beachline for dying sea turtles to strand ashore. In *C. mydas*, it is the juveniles that mostly inhabit such coastal area (LIMPUS *et al.* 2005), which may lead to higher stranding. In fact, *C. mydas* have also been the most stranded sea turtle in other parts of Brazil (northeastern region, FARIAS *et al.* 2019; southeastern region; TAGLIOLATTO *et al.* 2018; southern region; MONTEIRO *et al*. 2016). This is also the case for other parts of the word, including Mediterranean (SONMEZ, 2018) and Oceania (FLINT *et al.* 2017). Overall, the highest records of *C. mydas* is perhaps due to the species foraging strategy, which is mostly associated to shallow waters (CAMPOS & CADORNA, 2020; LIMA, MELO & FERREIRA, 2017). Ceará's coastal zone is known to be a significant site of sea turtle feeding (LIMA *et al*. 2013) and also as a migration path (NARO-MACIEL,2006).

The other three species that strand in the area also use Ceará as a feeding ground even tough with considerably lower frequencies in relation to *C. mydas*. The olive ridley turtle (*L. olivacea*), the second most abundant in strandings, uses Ceará as a foraging area (juveniles and adults) and a migratory corridor for reproduction (adult females) in French Guiana and Surinam (LIMA, MELO & FERREIRA, 2013; SILVA *et al*. 2011). This may explain why the number of juveniles is similar to the number of adults stranded in the region (further research is needed in order to test this hypothesis). The hawksbill turtle (*E. imbricata*), the third most frequently to strand in the region, migrate to Ceará after the nesting season in Bahia (MARCOVALDI *et al*. 2012) and it also uses Ceará's coast as a feeding ground (LIMA *et al.* 2013). The loggerhead turtle (*C. caretta*), the species that less frequently strand in the region, also uses Ceará as foraging area (LIMA, MELO & FERREIRA, 2013). This species is more abundant in the northernmost part of its distribution range in the western Atlantic (USA; LAMONT, FUJISAKI & CARTHY, 2014), which may explain its relatively rarity in the region.

The leatherback turtle (*Dermochelys coriacea*) is the only sea turtle species occurring in Brazil that does not strand in the studied area. This species has a preference for relatively cooler waters. Further south along the Brazilian coast, with comparatively lower temperature waters, this species relatively frequency only grows (Rio de Janeiro State, TAGLIOLATTO *et al*. 2018; Rio Grande do Sul State, MONTEIRO *et al* 2016).

The pattern of lack of seasonal and geographical variation in sea turtle strandings in the region has management implications. It implies that not any specific season of the year could be chosen for monitoring. Any future mitigation action efforts should be equally applied along all seasons. This differs from other parts of Brazil, where the frequency strandings vary seasonally (Rio Grande do Norte, FARIAS *et al.* 2019; Rio de Janeiro, TAGLIOLATTO *et al.* 2018, RGS MONTEIRO *et al*. 2016). Since the frequency of strandings also does not differ among the municipalities withing the study area, future mitigation action efforts should also take this aspect into account.

Another worrying aspect revealed by the present study is the overall health conditions of individuals before dying and stranding. The fibropapillomatosis presence in some turtles implies that these animals were already debilitated before death. This is because the tumors can block the sea turtle vision and the ability of swimming (HERBEST, 1994). Also, this disease can be a warning to water quality of our marine ecosystem in the world, once fibropapillomatosis can be positive associated to human activity (HERBEST, 1994) and it has been growing its frequency in touristic sites (USA; FOLEY *et al*. 2005).

As for the detected negative anthropic interaction, the evidence found in the present study of sea turtles found entangled in fishery nets likely hurting the animal is also a problem for sea turtles elsewhere (POLI et al. 2014; LIMA et al. 2001). In fact, this is a global threat to sea turtles (MONTEIRO *et al.* 2014; SNAPE *et al.* 2013.). Given the detection of this threat in the study area, it is here suggested that an awareness program be created focused on local fisherman and the community in general.

## 5. CONCLUSIONS

- Juvenile green turtle C*helonia mydas* is the most stranded sea turtle in the studied area.
- Overall, four sea turtle species strand in the area: *Chelonia mydas, Lepidochelys olivacea, Eretmochelys imbricata*, and *Caretta caretta* (ordered by stranding frequency).
- The number of strandings does not follow a seasonal or local pattern.
- Stranded sea turtles in the region are sometimes impacted by fibropapillomatosis or negative anthropogenic interaction.

**REFERENCES**

ABREU-GROBOIS, A e; PLOTKIN, P. (IUCN SSC Marine Turtle Specialist Group). 2008. *Lepidochelys olivacea*. **The IUCN Red List of Threatened Species 2008:** e.T11534A3292503. https://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T11534A3292503.en.

ALMEIDA, A. P.; MOREIRA, L. M. P.; BRUNO, S. C.; THOMÉ, J. C.A.; MARTINS, A. S.; BOLTEN, A. B.; BJORNDAL, K. A. Green turtle nesting on Trindade Island, Brazil: abundance, trends, and biometrics. **Endangered Species Research**, [S.L.], v. 14, n. 3, p. 193-201, 31 ago. 2011. Inter-Research Science Center. http://dx.doi.org/10.3354/esr00357.

BOLTEN, A. B. Techniques for measuring sea turtles. **Research and Management Techniques for the Conservation of Sea Turtles.** 1999. IUCN SSC Marine Turtle Specialist Group.

CAMPOS, P. e; CARDONA, L. Trade-offs between nutritional quality and abundance determine diet selection in juvenile benthic green turtles. **Journal Of Experimental Marine Biology And Ecology**, [S.L.], v. 527, p. 0-0, jun. 2020. Elsevier BV. http://dx.doi.org/10.1016/j.jembe.2020.151373.

CASALE, P. e; TUCKER, A.D. 2017. *Caretta caretta* (amended version of 2015 assessment). **The IUCN Red List of Threatened Species 2017**: e.T3897A119333622. https://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T3897A119333622.en.

FARIAS, D. S. D.; ALENCAR, A. E. B.B; BONFIM, A. C.; FRAGOSO, A.B.L.; ROSSI, S.; MOURA, G. J. B.; GAVILAN, S. A. SILVA, F. J. L. Marine turtles stranded in Northeastern Brazil: Composition, spatio-temporal distribution, and anthropogenic interactions. **Chelonia Conservation and Biology**. 2019.

FLINT, J.; FLINT, M.; LIMPUS, C. J.; MILLS, P. C. The impact of environmental factors on marine turtle stranding rates. **Plos One**, [S.L.], v. 12, n. 8, p. 0-0, 3 ago. 2017. Public Library of Science (PLoS). http://dx.doi.org/10.1371/journal.pone.0182548.

FOLEY, A. M..; SCHROEDER, B. A.; REDLOW, A. E.; FICK-CHILD, K. J.; TEAS, W. G.. Fibropapillomatosis in stranded green turtles (*Chelonia mydas*) from the eastern united states (1980–98): trends and associations with environmental factors. **Journal Of Wildlife Diseases**, [S.L.], v. 41, n. 1, p. 29-41, jan. 2005. Wildlife Disease Association. http://dx.doi.org/10.7589/0090-3558-41.1.29.

GIBBONS, J. W. e; LOVICH, J. E. Where has turtle ecology been, and where is it going? **Herpetologists' League**, Estados Unidos, v. 75, n. 1, p. 4-20. 2019

GODLEY, B. J.; BRODERICK, A. C.; COLMAN, L. P.; FORMIA, A.; GODFREY, M. H.; HAMANN, M.; NUNO, A.; OMEYER, L. C. M.; PATRÍCIO, A. R.; PHILLOTT, A. D. Reflections on sea turtle conservation. **Oryx**, [S.L.], v. 54, n. 3, p. 287-289, 23 abr. 2020. Cambridge University Press (CUP). http://dx.doi.org/10.1017/s003060532000016

GODLEY, B. J; LIMA, E.; ÅKESSON, S; BRODERICK, A. C.; GLEN, F; GODFREY, M. H.; LUSCHI, P; HAYS, G. C. Movement patterns of green turtles in Brazilian coastal waters described by satellite tracking and flipper tagging. **Marine Ecology Progress Series**, [S.L.], v. 253, n. -, p. 279-288, 2003. Inter-Research Science Center. http://dx.doi.org/10.3354/meps253279.

HART, K. M.; MOORESIDE, P. e; CROWDER, L. B. Interpreting the spatio-temporal patterns of sea turtle strandings: going with the flow. **Biological Conservation**, [S.L.], v. 129, n. 2, p. 283-290, abr. 2006. Elsevier BV. http://dx.doi.org/10.1016/j.biocon.2005.10.047.

HERBST, L. H. Fibropapillomatosis of marine turtles. **Annual Review Of Fish Diseases**, [S.L.], v. 4, p. 389-425, jan. 1994. Elsevier BV. http://dx.doi.org/10.1016/0959-8030(94)90037-x

ICMBio/MMA. **Livro Vermelho da Fauna Brasileira Ameaçada de Extinção**: Volume I / 1. ed. Brasília, DF. 2018.

LAMONT, M. M.; FUJISAKI, I. e; CARTHY, R. R. Estimates of vital rates for a declining loggerhead turtle (Caretta caretta) subpopulation: implications for management. **Marine Biology**, [S.L.], v. 161, n. 11, p. 2659-2668, 19 set. 2014. Springer Science and Business Media LLC. http://dx.doi.org/10.1007/s00227-014-2537-0.

LIMA, E.H.S.M.; MELO, M.T.D.M. e; FERREIRA, F.D.A. Registro de tartaruga oliva Lepidochelys olivacea (Eschscholtz, 1829) na pescaria de currais de pesca, Ceará, Brasil. 2018.

LIMA, E.H.S.M.; MELO, M.T.D.; GODFREY, M.H.; BARATA, P.C.R. Sea turtle in the waters of Almofala Ceará, in northeastern Brazil 2001-2010. **Marine Turtle Newsletter.** V. 137, abril, 2013.

LIMA, E. P.; WANDERLINDE, J.; ALMEIDA, D. T. de; LOPEZ, G.; GOLDBERG, D. W. Nesting Ecology and Conservation of the Loggerhead Sea Turtle (Caretta caretta) in Rio de Janeiro, Brazil. **Chelonian Conservation and Biology**, [S.L.], v. 11, n. 2, p. 249-254, dez. 2012. Chelonian Conservation and Biology Journal. http://dx.doi.org/10.2744/ccb-0996.1.

LIMA, E. H. S. M. Ocorrências de tartarugas marinhas mortas em Almofala, Ceará durante a campanha 2000. In: ENCONTRO DE ZOOLOGIA DO NORDESTE, 13., 2001, São Luiz. Resumos..., São Luiz: Universidade Federal do Maranhão, 2001, p.157

LIMPUS, C. J.; LIMPUS, D. J.; ARTHUR, K. E.; PARMENTER, C. J. Monitoring of green turtle population dynamics in Shoalwater Bay: 2000–2004. **Research Publication No. 83, Great Barrier Reef Marine Park Authority Research Publication Series**. 2005.

MACHOVSKY-CAPUSKAA, G. E.; ANDRADES, R. e; SANTOS, R.G. Debris ingestion and nutritional niches in estuarines and reef green turtles. **Marine Polution Bulletin.** 2020

MARCOVALDI, M. A.; LOPEZ, G. G.; SOARES, L. S.; LÓPEZ-MENDILAHARSU, M. Satellite tracking of hawksbill turtles Eretmochelys imbricata nesting in northern Bahia, Brazil: turtle movements and foraging destinations. **Endangered Species Research**, [S.L.], v. 17, n. 2, p. 123-132, 8 maio 2012. Inter-Research Science Center. http://dx.doi.org/10.3354/esr00421.

MARCOVALDI, M.A. e; MARCOVALDI, G.G. dei.; Marine turtles of Brazil: The history and structure of projeto TAMAR-IBAMA. **Biological Conservation.** V.99, p35-41, fev, 1999.

MONTEIRO, D. S.; ESTIMA, S. C.; GANDRA, T. B. R.; SILVA, A. P.; BUGONI, L.; SWIMMER, Y.; SEMINOFF, J. A.; SECCHI, E. R. Long-term spatial and temporal patterns of sea turtle strandings in southern Brazil. **Marine Biology**, [S.L.], v. 163, n. 12, 4 nov. 2016. Springer Science and Business Media LLC. http://dx.doi.org/10.1007/s00227-016-3018-4.

MORAIS, J. O.; FREIRE, G.S.S.; PINHEIRO, L. S.; SOUZA, M.J.N.; CARVALHO, A. M.; PESSOA, P. R. S.; OLIVEIRA, S. H. H. Ceará. **Ministério do Meio Ambiente.** 2006. https://www.mma.gov.br/estruturas/sqa_sigercom/_arquivos/ce_erosao.pdf

MORTIMER, J.A e; DONNELLY, M. (IUCN SSC Marine Turtle Specialist Group). 2008. *Eretmochelys imbricata*. **The IUCN Red List of Threatened Species 2008**: e.T8005A12881238. https://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T8005A12881238.en.

NARO-MACIEL, E.; BECKER, J. H.; LIMA, E. H. S. M.; MARCOVALDI, M. A.; DESALLE, R.. Testing Dispersal Hypotheses in Foraging Green Sea Turtles (Chelonia mydas) of Brazil. **Journal Of Heredity**, [S.L.], v. 98, n. 1, p. 29-39, 7 dez. 2006. Oxford University Press (OUP). http://dx.doi.org/10.1093/jhered/esl050

POLI, C.; LOPEZ, L. C. S..; MESQUITA, D. O.; SASKA, C.; MASCARENHAS, R. Patterns and inferred processes associated with sea turtle strandings in Paraíba State, Northeast Brazil. **Brazilian Journal Of Biology**, [S.L.], v. 74, n. 2, p. 283-289, maio 2014. FapUNIFESP (SciELO). http://dx.doi.org/10.1590/1519-6984.13112.

REIS, E. C.; GOLDBERG, D. W.. Biologia, ecologia e conservação de tartarugas marinhas. in **Reis, Estéfane Cardinot; Curbelo-Fernandez, Maria Patrícia, editoras. Mamíferos, quelônios e aves: caracterização ambiental regional da Bacia de Campos, Atlântico Sudoeste. Rio de Janeiro: Elsevier. Habitats**, v. 7, chap. 5. p. 63-89, 2017.

SANTOS, B. S.; FRIEDRICHS, M. A. M.; ROSE, S. A.; BARCO, S. G.; KAPLAN, D. M. Likely locations of sea turtle stranding mortality using experimentally-calibrated, time and space-specific drift models. **Biological Conservation**, [S.L.], v. 226, p. 127-143, out. 2018. Elsevier BV. http://dx.doi.org/10.1016/j.biocon.2018.06.029.

SANTOS, A. J. B.; FREIRE, E. M. X.; BELLINI, C.; CORSO, G.. Body Mass and the Energy Budget of Gravid Hawksbill Turtles (Eretmochelys imbricata) during the Nesting Season. **Journal Of Herpetology**, [S.L.], v. 44, n. 3, p. 352-359, set. 2010. Society for the Study of Amphibians and Reptiles. http://dx.doi.org/10.1670/08-287.1.

SEMINOFF, J.A. (Southwest Fisheries Science Center, U.S.). 2004. *Chelonia mydas*. **The IUCN Red List of Threatened Species 2004**: e.T4615A11037468. https://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en.

SILVA, A. C. C. D. da; SANTOS, E. A. P. dos; CASTILHOS, J. C. de; OLIVEIRA, F. L. D. C.; WEBER, M. I.; BATISTA, J. A. F.; SERAFINI, T. Z. Satellite-tracking reveals multiple foraging strategies and threats for olive ridley turtles in Brazil. **Marine Ecology Progress Series**, [S.L.], v. 443, p. 237-247, 20 dez. 2011. Inter-Research Science Center. http://dx.doi.org/10.3354/meps0942

SILVA, A. C. C.D. da; CASTILHOS, J. C. de; LOPEZ, G. G.; BARATA, P. C. R. Nesting biology and conservation of the olive ridley sea turtle (Lepidochelys olivacea) in Brazil, 1991/1992 to 2002/2003. **Journal Of The Marine Biological Association Of**

**The United Kingdom**, [S.L.], v. 87, n. 4, p. 1047-1056, 30 jul. 2007. Cambridge University Press (CUP). http://dx.doi.org/10.1017/s0025315407056378.

SNAPE, R. T. E.; BETON, D.; BRODERICK, A. C.; ÇIÇEK, B. A.; FULLER, W. J.; ÖZDEN, Ö.; GODLEY, B. J. Strand Monitoring and Anthropological Surveys Provide Insight into Marine Turtle Bycatch in Small-Scale Fisheries of the Eastern Mediterranean. **Chelonian Conservation and Biology**, [S.L.], v. 12, n. 1, p. 44-55, jul. 2013. Chelonian Conservation and Biology Journal. http://dx.doi.org/10.2744/ccb-1008.1.

SOARES, M. O.; TEIXEIRA, C. E. P.; BEZERRA, L. E. A.; PAIVA, S. V.; TAVARES, T. C. L.; GARCIA, T. M.; ARAUJO, J. T. de; CAMPOS, C. C.; FERREIRA, S. M. C.; MATTHEWS-CASCON, H. Oil spill in South Atlantic (Brazil): environmental and governmental disaster. **Marine Policy**, [S.L.], v. 115, p. 0-0, maio 2020. Elsevier BV. http://dx.doi.org/10.1016/j.marpol.2020.103879.

TAGLIOLATTO, A. B.; GOLDBERG, D. W.; GODFREY, M. H.; MONTEIRO-NETO, C. Spatio-temporal distribution of sea turtle strandings and factors contributing to their mortality in south-eastern Brazil. **Aquatic Conservation**: Marine and Freshwater Ecosystems, [S.L.], v. 30, n. 2, p. 331-350, 14 dez. 2019. Wiley. http://dx.doi.org/10.1002/aqc.3244.

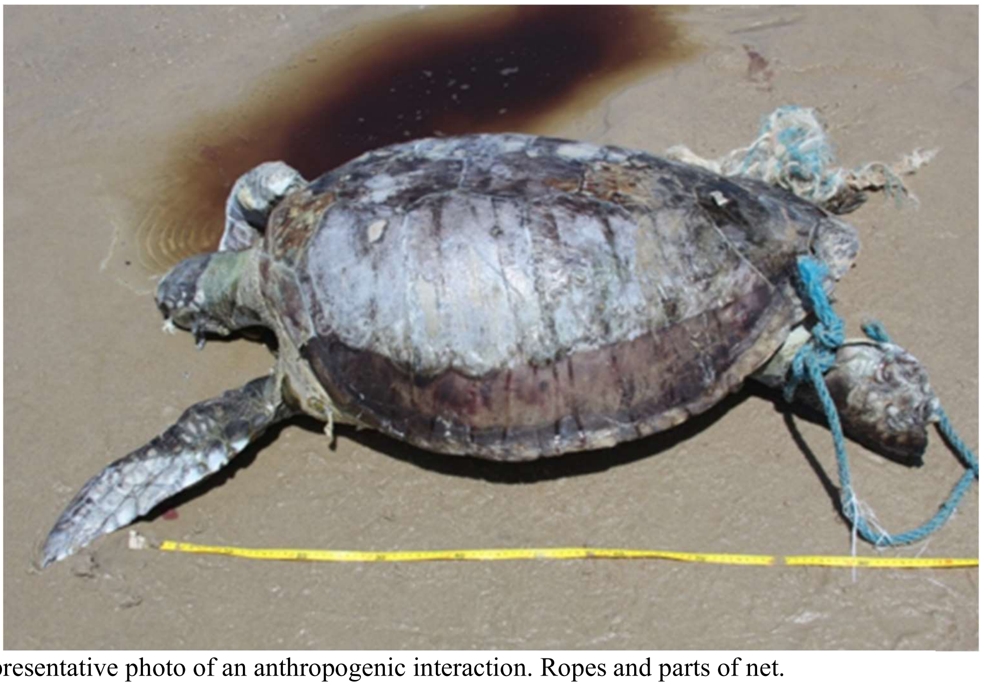
WALLACE, B. P.; LEWISON, R. L.; MCDONALD, S. L.; MCDONALD, R. K.; KOT, C. Y.; KELEZ, S.; BJORKLAND, R. K.; FINKBEINER, E. M.; HELMBRECHT, S.; CROWDER, L. B. Global patterns of marine turtle bycatch. **Conservation Letters**, [S.L.], v. 3, n. 3, p. 131-142, 5 abr. 2010. Wiley. http://dx.doi.org/10.1111/j.1755-263x.2010.00105.x.

WALLACE, B.P., TIWARI, M. e; GIRONDOT, M. 2013. *Dermochelys coriacea*. **The IUCN Red List of Threatened Species 2013**: e.T6494A43526147. https://dx.doi.org/10.2305/IUCN.UK.2013-2.RLTS.T6494A43526147.en.

## APPENDIX A – PHOTOS

All pictures belong to the Associação de Pesquisa e Conservação de Ecossistemas Aquáticos – AQUASIS photo archives.

Representative photo of an anthropogenic interaction. Ropes and a cut in the neck.



Representative photo of an anthropogenic interaction. Ropes and parts of net.

Representative photo of a tumor of fibropapillomatosis.

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Representative photo of an anthropogenic interaction. Lobster trap (manzuá).

Representative photo of an anthropogenic interaction. Lobster trap (manzuá).

Representative photo of a case of amputation.