

Praia Grande of Príncipe Island (Gulf of Guinea): an important nesting beach for the green turtle *Chelonia mydas*

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Loureiro, N.S., H. Carvalho & Z. Rodrigues 2011. Praia Grande of Príncipe Island (Gulf of Guinea): an important nesting beach for the green turtle *Chelonia mydas*. Archipelago. *Arquipelago*. Life and Marine Sciences 28: 89-95.

The beach Praia Grande, on Príncipe Island (Gulf of Guinea, West Africa), hosts a green turtle rookery. A total of 219 clutches with an average size of 111 eggs were laid by the 88 females that nested there during the 2007-2008 nesting season. During the nesting season 2009-2010, 315 clutches, averaging 104 eggs, were laid by the 112 females that were recorded. During both seasons, nesting began in early September and lasted until late February, with a peak in December-January. In the 2009-2010 nesting season, the clutch frequency was 2.7 (SD = 1.3) and the average re-nesting interval 12.3 days (SD = 1.8). The average incubation duration of the clutches that were incubated in situ, shaded by the existing natural vegetation, was 60.4 days (SD = 1.4). However, throughout the 2007-2008 nesting season almost all the clutches were incubated in an unshaded hatchery and the average incubation duration was 3.2 days shorter. The data published here is the first report concerning the green turtle rookery on Praia Grande, Príncipe Island.

Key words: West Africa, Príncipe Island, nesting beach, *Chelonia mydas*, green turtle

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INTRODUCTION

The Democratic Republic of São Tomé and Príncipe, the second smallest African country, consists of a volcanic archipelago with two inhabited islands in the Gulf of Guinea (West Africa), straddling the Equator (Fig. 1). Príncipe, the smaller of the two islands (114 km²), has a tropical moist climate and luxuriant vegetation. The island has 24 sandy beaches less than 750 m in length and three beaches extending from 900 to 1,400 m. The beaches are located mainly on the northern, eastern and southern coasts of the island.

Three sea turtle species have been confirmed as nesting at Príncipe Island: green turtle *Chelonia mydas* (local name: 'mão branca'), hawksbill turtle *Eretmochelys imbricata* ('sada' or 'tartaruga de caco') and leatherback *Dermochelys*

coriacea ('ambulância' or 'Fernando Pó'). Occasionally, adults of the olive ridley *Lepidochelys olivacea* ('tâtô') and the loggerhead *Caretta caretta* ('cabeça grande') are found in the nearshore waters of the island (Graff 1996; Fretey 2001).

On the basis of mitochondrial DNA studies, Formia et al. (2006) suggested that the archipelago's green turtle rookery forms a single Management Unit, an important biodiversity concept introduced by Moritz (1994) in order to strengthen the need for adopting regional conservation measures.

São Tomé and Príncipe is not considered a major green turtle nesting area in the Atlantic (Godley et al. 2001a), but listed as a lesser one (Brongersma 1995; Fretey 2001; Seminoff 2004; Formia et al. 2006). However, accurate and updated information concerning sea turtles in São

Tomé and Príncipe remains scarce, a serious obstacle for ranking the regional importance of the archipelago for sea turtles.

To our knowledge, only one estimate of the nesting population of green turtles on Príncipe Island has been published; Formia et al. (2006) estimated that 75-100 green turtles nest per year, a value based on unpublished data communicated by J.F. Dontaine.

Here, we report on the results of a nesting beach survey study carried out during the 2009-2010 season, alongside an effort to protect nesting females and nests at Praia Grande on Príncipe Island. Available data from a previous nesting season (2007-2008) is included to emphasise the regional importance of this beach for green turtles in the eastern Atlantic.

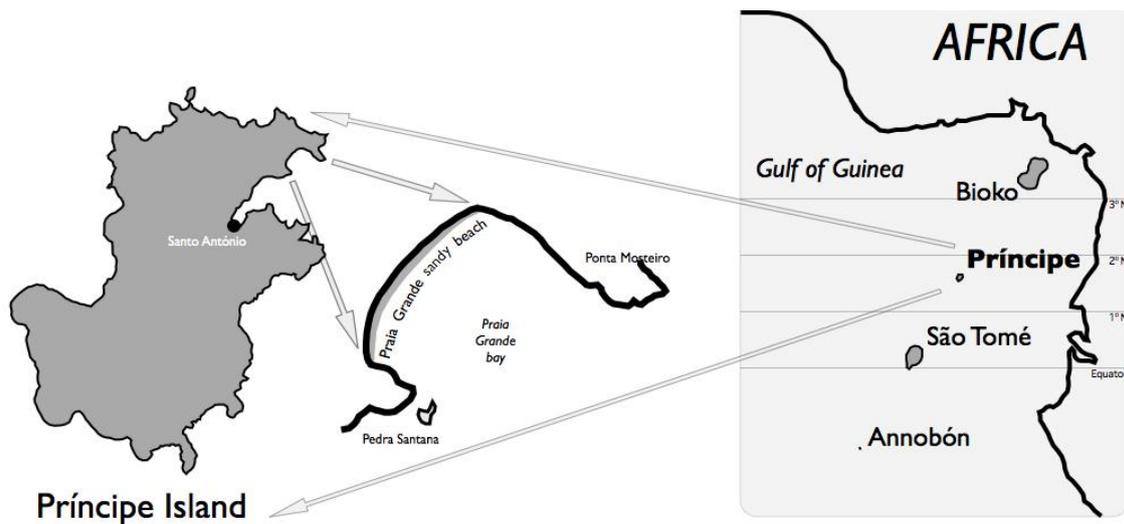


Fig. 1. Partial view of the western coast of Africa and the four islands in the Gulf of Guinea, with a focus on Príncipe Island and on the Praia Grande nesting beach.

MATERIAL AND METHODS

Praia Grande is a 1,380 m long, white sandy beach protected by a bay and located on the northeast coast of Príncipe Island (geographical coordinates of the center of the beach are 1°40'15" N and 7°26'48" E) (Fig. 1).

The NGO MARAPA (Sea, Environmental and Traditional Fisheries) began managing a sea turtle protection project in 2002 at São Tomé and Príncipe, including Praia Grande.

Due to logistic and funding difficulties the beach monitoring has been irregular. Tagging and observation data for Praia Grande were not stored in a standardised and easily accessible format and, consequently, the available data were sometimes difficult to interpret. In 2009 a new sea turtle project, 'Programa SADA', started at Príncipe Island, managed by the University of

Algarve, Portugal, under an agreement with the Regional Government of Príncipe Island.

BEACH SURVEYS

During the 2007-2008 nesting season, monitoring and protection activities were ensured by local unpaid collaborators coordinated by Z. Rodrigues. Night patrols began on 1 September and ran until 30 April. The beach team recorded all nesting events, tagged and measured nesting females. Clutches were relocated to a hatchery, emergences were recorded and hatchlings released. Night patrols generally began at 18 hours and lasted until 23 hours or later, depending on the presence of nesting females on the beach. Despite a noticeable motivation, beach patrols were not continuous, in most part due to persistent rainfall and other tempestuous weather conditions, causing some gaps in the datasets. During the 2009-2010 season, field work

activities were ensured by local workers from the 'Programa SADA', and coordinated by Z. Rodrigues. Night patrols began on 1 September and ran continuously until 28 February, generally from 18 hours until 02 hours or later, depending on the presence of nesting females on the beach. Each nesting female was identified, measured, tagged (if not already tagged) and allowed to return to sea. Nests were recorded but eggs were not relocated. The hatchery that had been used throughout the 2007-2008 nesting season was intentionally abandoned in the 2009-2010 season in favour of in situ incubation. The hatchery had been constructed in a sunny location closer to the sea. However, at Praia Grande the nesters always choose to dig egg chambers in places that were covered by the abundant vegetation found on the beach. From 1 March to 30 April, the surveying effort was reduced and focus was given to hatchling emergences and dash to reach the sea.

During the 2007-2008 nesting season, each nesting female was tagged with one PROTOMAC flipper tag (Inconel; KUD series) on the front flipper, punching the first large scale. Carapaces were measured with a flexible fiberglass tape measure and the curved carapace length notch to tip (CCL_{n-t}) was the adopted measurement. In the 2009-2010 nesting season, each nesting female was tagged with one PIT tag (AVID, FDX-B, 15-digit numeric, 134.2 kHz) inserted under the second large scale, and two ACCSTR (Inconel; TTY, YYN or UUG series) or PROTOMAC (KUD series) flipper tags, placed on the front flippers, between the first and second large scales. The adopted measurement for the carapaces changed to the minimum curved carapace length (CCL_{min}) as recommended by Bolten (1999).

RENESTING INTERVALS COMPUTATION

Prior to computing the average renesting intervals, and in line with the method used by Broderick et al. (2003) to estimate the corrected clutch frequency, recorded values greater than 18 days were excluded from the original datasets. The average clutch size values obtained for both nesting seasons were not comparable due to different methods used: eggs were counted during relocation throughout the 2007-2008 nesting while throughout the 2009-2010 season eggs were

counted during nest analysis, two days after the main emergence.

RESULTS

Praia Grande was the most visited beach by nesting sea turtles on Príncipe Island. The green turtle is the species with the highest occurrence, while hawksbill turtles and leatherbacks were occasional nesters.

Nesting occurred between early September and late February, peaking during the months of December and January. The weekly time-scale distribution of green turtles in the Praia Grande environment during the 2007-2008 and 2009-2010 nesting seasons is shown in Fig. 2. The number of clutches laid by the number of nesters for both nesting seasons is shown in Fig. 3.

THE 2007-2008 NESTING SEASON

A total of 88 green turtle nesters visited Praia Grande, laying on average 2.5 clutches ($SD = 1.4$; range = 1 to 7), with a renesting interval of 12.7 days ($SD = 1.6$). Of these, 85 nesters arrived without flipper tags and were tagged. The other females arrived carrying tags, but it was not possible to retrieve any information concerning application date and place. The average CCL_{n-t} was 99.7 cm ($n = 86$; $SD = 5.3$; range = 86.0 to 114.0).

From a total of 219 green turtle clutches laid at Praia Grande, 208 were relocated to the hatchery while 11 remained in situ. The average clutch size was 111 eggs ($n = 208$; $SD = 23$), and the average incubation duration in the hatchery was 57.2 days ($n = 200$; $SD = 4.8$). Hatchling emergence from in situ nests was not monitored.

THE 2009-2010 NESTING SEASON

A total of 122 green turtle adult females came ashore at Praia Grande. Of these, 112 succeeded in nesting, laying on average 2.7 clutches ($SD = 1.3$; range = 1 to 6), with an average renesting interval of 12.3 days ($SD = 1.8$). A total of 315 green turtle nests were recorded at Praia Grande. As the hatchery had been deactivated, almost all the clutches remained in situ and only a few were relocated to safer sites. The average incubation

duration in situ was 60.4 days ($n = 230$; $SD = 1.4$), and the average clutch size was 104 eggs ($n = 228$; $SD = 22$).

According to our observations, the nesters could be divided into two groups: (1) 'early nesters', comprising 29 green turtle adult females (28 nesters) that began to come ashore during the first week of September, and after the first week of December apparently none of these remained in the proximity of Praia Grande, and (2) 'principal nesters', comprising 93 adult females

(84 nesters) that began to come ashore during the second half of November, with some remaining until the third week of February.

Of the 122 adult females, two arrived with tags; one with a KUD series tag applied during the 2007-2008 nesting season at Praia Grande, and the other with a similar tag applied in the 2006-2007 nesting season at Praia Ribeira Izé (E. Neto, MARAPA, pers. comm.), which is located 13.5 km from Praia Grande. The average CCL_{min} was 98.8 cm ($SD = 5.4$; range = 88.3 to 113.0).

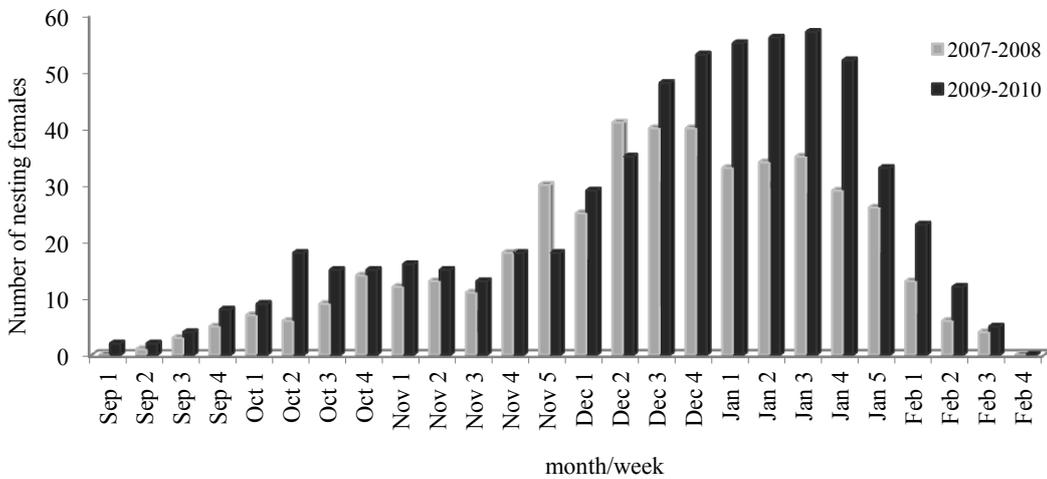


Fig 2. Number of nesting females per week in the Praia Grande environment during the 2007-2008 and 2009-2010 seasons.

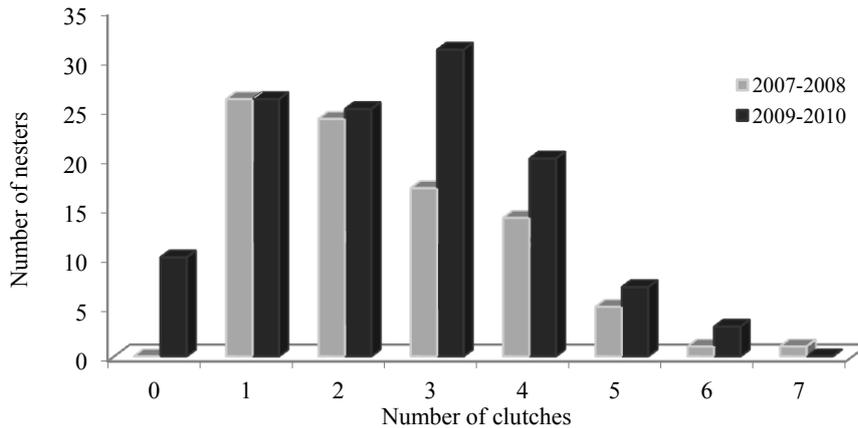


Fig 3. Number of clutches laid by the number of nesting females at Praia Grande throughout the 2007-2008 and 2009-2010 seasons.

SITE FIXITY AND LONG DISTANCE MOVEMENTS

Several occurrences reported in this study may shed some light on other features of adult female green turtles of the Príncipe Island rookery, namely site fixity and long distance movements. A nesting female tagged at Praia Grande in the 2007-2008 season was observed nesting on the same beach in the 2009-2010 season. Two similar cases include a nesting female tagged in January 2008 at Praia Grande that was found laying eggs in February 2010 at Praia Sêca on the southeast coast of the island, 15 km from the previous nesting beach; and a nesting female recorded on Praia Grande during the 2009-2010 season that had been tagged in 2006-2007, 13.5 km away at Praia Ribeira Izé. A nesting female tagged in September 2009 at Praia Grande that renested the last time in October 2009 was found (dead, entangled in a fishing net) 2,600 km away from Príncipe Island, in the coastal waters of Sierra Leone, in February 2010 (E. Neto, MARAPA, pers. comm.). This incident provides the first information about the long distance movements of a female green turtle after nesting at Praia Grande.

DISCUSSION

REMIGRATION INTERVAL

Miller (1997) stated an overall average remigration interval to breeding of 2.86 years for green turtles. Tröeng & Chaloupka (2007) found that in the Tortuguero rookery, Costa Rica, the most common modes of remigration are 2 and 3 years, but stated that the remigration intervals are shorter there than for other green turtle populations due to various reasons, such as environmental conditions. Broderick et al. (2001) concluded that at the Alagadi Beach rookery in Cyprus, adult females often shift between different remigration intervals.

Praia Grande was visited by 88 green turtle nesters throughout the 2007-2008 nesting season and by 122 adult females throughout the 2009-2010 nesting season. Only one nester tagged during the first study period was observed during the second.

CLUTCH FREQUENCY

An overall average clutch frequency, or number of clutches per season, for green turtles is given as 2.93 (Miller 1997), ranging from one to seven clutches (Carr et al. 1978). Broderick et al. (2003) estimated an average of 3.0 clutches per season at the Alagadi Beach rookery in Cyprus.

Different speculations could contribute to explain the disparity in the number of clutches per nester between the two periods on Praia Grande (Fig. 3). During the 2007-2008 nesting season, most nesting females were observed laying only one clutch. During the 2009-2010 nesting season, 31 turtles were observed laying 3 clutches. In the 2007-2008 nesting season the maximum clutch frequency was 7, and 6 in the 2009-2010 nesting season.

One possible explanation for the differences in average clutch frequency might be the smaller survey effort throughout the 2007-2008 nesting season, which resulted in a higher proportion of unmonitored nesting events. The occurrence of a transient behaviour of some nesting females is another possibility presented by Tröeng & Chaloupka (2007), to explain the single clutch per season proportion. Unquestionably, more studies will be needed to improve our level of understanding of the behaviour of the Príncipe Island's green turtle rookery, as we have only data from two seasons.

INCUBATION DURATION

A difference of 3.2 days in average incubation time was found between the two seasons, the 2007-2008 season having the shortest incubation period. A major explanation is evidently the incubation environment, i.e. a hatchery was used in the 2007-2008 season. Unfortunately, sand and clutch temperatures were never measured at Príncipe Island, although, it is to be expected that the sand is warmer and drier in a sunny place. As incubation duration is related to the thermal conditions of the egg chamber (Godley et al. 2001b), the mentioned difference is undoubtedly related to the use of the hatchery.

RENESTING INTERVAL

The overall average renesting interval for green turtles was given by Miller (1997) as of 12.0 days, and concurs with our results, which were

12.7 and 12.3 for the two nesting seasons, respectively. Carr et al. (1978) found a range between 9 and 15 days in a study in the West Caribbean.

SITE FIXITY

The high degree of site fixity is generally accepted as a species characteristic (Plotkin 2003). We do not have data as yet to discuss the degree of site fixity at Praia Grande. Nevertheless, we found nesters ($n = 5$) that laid six and seven clutches at Praia Grande throughout the same nesting season, which shows a strong site fixity. On the other hand, as mentioned above, one nester tagged at Praia Grande in 2008 was observed laying eggs 15 km away in 2010 and a female tagged 13.5 km away in 2006-2007 was observed nesting at Praia Grande in the 2009-2010 season.

CONCLUSION

This report is a first approach and an initial output from a beach centered study on the green turtle population at Praia Grande on Príncipe Island. Future campaigns of beach surveying, sea turtle protection and research will decisively contribute to consolidate the emerging knowledge related to this rookery.

The presented data point towards a confirmation of the size of the green turtle nesting female population estimated by Formia et al. (2006). Consequently, the regional importance of the Príncipe Island green turtle rookery could be strengthened in the near future, displaying a similar or larger size than the São Tomé Island rookery (80-100 females; Formia et al. 2006) and a not much smaller size than the Bioko Island rookery (415-550 females; Tomás et al. 2000).

Príncipe Island is essentially inhabited by very poor communities that have strong ties to the sea. Tourism is in its initial development stage, agriculture has returned to an underdeveloped state and alternative employment opportunities are low. The main protein source for human consumption comes from the sea and, consequently, sea turtles are constantly at risk, particularly green turtle meat and eggs, which are traditionally consumed by the local population.

Conservation efforts undertaken at Príncipe, initially by the NGO MARAPA and currently by the 'Programa SADA', have contributed to the sharp decline in captures and deaths of sea turtles. The degree of success of turtle conservation on Príncipe will be largely determined by the continuity of these conservation and awareness efforts, as well as, the support of the Regional Government, which has recently passed a law prohibiting the capture and marketing of sea turtles, and is currently penalised by a heavy fine.

At present, one of the main interrogating challenges is to accurately explain the causes of the green turtle nesting concentration at Praia Grande, to identify the preferred and occasional interesting places and to describe the movements of the nesters before and after coming ashore at other nesting beaches on Príncipe Island. Certainly, future surveys are needed to attain the accurate description of the remigration interval of the Príncipe Island green turtle rookery, the number of recruited nesters per nesting season, and other critical factors, such as hatching success rate and sex ratios, which are required to understand the dynamics of the entire population and aid in their conservation.

ACKNOWLEDGEMENTS

This paper is an output of the 'Programa SADA' (www.tartarugasstomeprincipe.org), launched at Príncipe Island, by the University of Algarve, Portugal. The authors thank the 'Oceanário de Lisboa' who provided funds to the 'Programa SADA', Nuno Viegas Santos (Arto Carpus Castelo Foundation) and Leonor Sardinha for the same reason, and thank the President of the Regional Government of Príncipe Island for his invaluable cooperation to successfully carry-out the various initiatives under the 'Programa SADA'. The authors want to thank NGO MARAPA for permission to use the 2007-2008 nesting season data. We also thank Damião Matos and Daniel Ramos for daily collaboration and Nuno Marques Pereira (DMV, 'Oceanário de Lisboa') for fruitful talks about wildlife conservation strategies. Peter Eliazar supplied us with ACCSTR flipper tags.

REFERENCES

- Bolten, A.B. 1999. Techniques for Measuring sea Turtles. Pp. 110-114 in: Eckert, K.L., K.A. Bjorndal, F.A. Abreu-Grobois & M. Donnelly (Eds). *Research and Management Techniques for the Conservation of Sea Turtles*. IUCN/SSC Marine Turtle Specialist Group Publication No. 4. Washington, DC. 235 pp.
- Broderick, A.C., B.J. Godley & G.C. Hays 2001. Trophic status drives interannual variability in nesting numbers of marine turtles. *Proceedings of the Royal Society of London B* 268(1475): 1481-1487.
- Broderick, A.C., F. Glen, B.J. Godley & G.C. Hays 2003. Variation in reproductive output of marine turtles. *Journal of Experimental Marine Biology and Ecology* 288(1): 95-109.
- Brongersma, L.D. 1995. Marine Turtles of the Eastern Atlantic Ocean. Pp. 407-416 in: Bjorndal K.A. (Ed.). *Biology and Conservation of Sea Turtles*. Revised Edition. Smithsonian Institution Press. Washington, D.C. 615 pp.
- Carr, A., M.H. Carr & A.B. Meylan 1978. The ecology and migrations of sea turtles, 7. The West Caribbean colony. *Bulletin of the American Museum of Natural History* 162(1): 1-46.
- Formia, A., B.J. Godley, J.F. Dontaine & M.W. Bruford 2006. Mitochondrial DNA diversity and phylogeography of endangered green turtle (*Chelonia mydas*) populations in Africa. *Conservation Genetics* 7(3): 353-369.
- Fretey, J. 2001. Biogeography and Conservation of Marine Turtles of the Atlantic Coast of Africa. CMS Technical Publication 6. UNEP/CMS Secretariat, Bonn. 424 pp.
- Godley, B.J., A.C. Broderick & G.C. Hays 2001a. Nesting of green turtles (*Chelonia mydas*) at Ascension Island, South Atlantic. *Biological Conservation* 97: 151-158.
- Godley, B.J., A.C. Broderick & N. Mrosovsky 2001b. Estimating hatchling sex ratios of loggerhead turtles in Cyprus from incubation durations. *Marine Ecology Progress Series* 210: 195-201.
- Graff, D. 1996. Sea Turtle Nesting and Survey in Sao Tomé. *Marine Turtle Newsletter* 75: 8-12.
- Miller, J.D. 1997. Reproduction in Sea Turtles. Pp. 51-81 in: P.L. Lutz & J.A. Musick (Eds). *The Biology of Sea Turtles*. CRC Press, Boca Raton. 432 pp.
- Moritz, C. 1994. Defining 'Evolutionary Significant Units' for conservation. *Trends in Ecology & Evolution* 9(10): 373-375.
- Plotkin, P. 2003. Adult Migrations and Habitat Use. Pp. 225-241 in: P.L. Lutz, J.A. Musick & J. Wyneken (Eds). *The Biology of Sea Turtles*. Vol II. CRC Press, Boca Raton. 496 pp.
- Seminoff, J.A. 2004. Green turtle (*Chelonia mydas*) - 2004 Global Status Assessment. MTSG - Marine Turtle Specialist Group, Species Survival Commission. D. Crouse & N. Pilcher (Evaluators). www.iucn.mtsg.org/red_list/cm/MTSG_Chelonia_mydas_assessment_expanded-format.pdf.
- Tomás, J., J. Castroviejo & J.A. Raga 2000. Sea turtles in the South of Bioko Island (Equatorial Guinea), Africa. Pp. 247-250 in: Kalb, H. & T. Wibbels (Compilers). Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation. *NOAA Technical Memo*. NMFS-SEFSC-443: 291 pp.
- Troëng, S. & M. Chaloupka 2007. Variation in adult annual survival probability and remigration intervals of sea turtles. *Marine Biology* 151(5): 1721-1730.

Accepted 03 October 2011.