

## REFERENCES

- Mendonça, V. M. 2001. Ecology of Sea Turtles in the Sultanate of Oman. Progress Report. Ministry of Regional Municipalities and Environment, Muscat, Oman. 66 pp.
- Ross, J. P. and M.A. Barwani. 1982. Review of sea turtles in the Arabian area. In Biology and Conservation of Sea Turtles. K. A. Bjorndal (Ed). Smithsonian Institution Washington, DC, USA.
- Salm, R. V. 1991. Turtles in Oman: Status, Threats and Management Options. Scientific Results of the IUCN Coastal Zone Management Project. IUCN/Ministry of Commerce and Industry, Muscat, Oman. 32 pp.
- Stancyk, S. E. 1995. Non-human predators of sea turtles and their control. In: Bjorndal, K. A. (Ed.). Biology and Conservation of Sea Turtles. Revised Edition. Washington, DC: Smithsonian Institution Press. pp.139-152.

## TEMPORARY SEQUENCES OF OVOPOSITION IN LOGGERHEAD FEMALES FROM THE CAPE VERDE ISLANDS

Ana Diaz Merry and Luisfepelo López-Jurado

Departamento de Biología, Facultad de Ciencias del Mar Universidad de Las Palmas de Gran Canaria, 35017 Las Palmas, Canary Islands, Spain

## INTRODUCTION

Nesting population of *Caretta caretta* in the island of Boavista (Cabo Verde, western Africa, FIGURE 1) has recently been discovered and, since 1998, it has been the purpose of management directed towards its conservation and to study the most significant aspects of their reproductive biology. This population consists of small-sized females; possibly due to the human predatory pressure for years, which could have resulted in a decrease of mean body size of females (Ballell et al., this volume).

Nesting behavior of marine turtles has largely been studied for years (Carr, 1982; Dodd Jr, 1988; Hailman & Elowson, 1992; Hendrickson, 1995; Miller, 1997) probably because it is the only time of their lifetime that they are on land and they are easily observed. Therefore, analysis of nesting behavior is a basic tool to characterize a colony, and subsequently compare it with other populations.

Our goal is to know the most important aspects of nesting behavior of females from Boavista island, especially the total nesting time and the duration of nesting phases (Dodd Jr, 1988; Hailman & Elowson, 1992; Hendrickson, 1995), and, also, the successful nesting of female emergences. It is possible that some differences in duration of nesting behavior may exist between females of different sizes.

Later, we compare these results with those of other known populations to check out if there are differences.

## MATERIAL AND METHODS

During the year 2000 nesting season of the loggerhead in Boavista, we measured temporal patterns of nesting behavior of 81 female loggerheads. Night patrols were made along three beaches at the southeastern coast of the island, with different features: Ervatão, Ponta Cosme and Calheta.

The number of emergences with nest were differentiated from those that were only nesting attempts to check nesting success, depending usually on beach characteristics (Hendrickson, 1995).

When a turtle was met, the time and the phase of nesting at that moment was recorded. The nesting time was considered sensu stricto as in Hailman & Elowson (1992), as well as the duration of

the different phases: nest preparation and egg-chamber digging, egg laying, and filling the chamber and covering the premises (Dodd Jr, 1988; Hailman & Elowson, 1992; Hendrickson, 1995). The phase of ascent to the beach was rejected, because the time check was difficult to measure in the first part of the process, as well as the return to the surf, because some of the females were handled when returning to the sea.

## RESULTS

From the 1,188 emergences of females of *Caretta caretta* observed during the year 2000 nesting season, only 44.2% of them achieved successful nestings, while 55.7% were aborted nesting attempts. If we analyze these results between the three beaches considered, we see that in Calheta the percentage of emergences with successful nesting is 67.5% (N=80), in Ponta Cosme is a little higher than average (54.4%, N=606), and in Ervatão the percentage diminishes to 39.0% (N=502).

The nesting time sensu stricto (Hailman & Elowson, 1992) was 67.4 minutes (SD=16.97, Range=39.0-140.0 minutes, N=81). If we compare this result between the three beaches, we see that there are no significant differences (H corrected=2.701, p=0.26).

The duration of the three phases considered was as follows: digging the egg chamber was 22.6 minutes (SD=12.6, Range=10.0-90.0, N=81); mean egg laying time was 20.9 minutes (SD=10.6, Range=11.0-75.0, N=81); and covering the nest extended to 23.9 minutes (SD=7.4, Range=10.0-49.0, N=81). If we compare these results between beaches, we do not find any significant differences in either digging the egg chamber or in covering the nest (digging egg chamber: H corrected=1.338, p=0.51; covering the premises?: H corrected=2.06, p=0.35), but some differences appeared in egg laying duration (H corrected=7.435, p=0.02).

There is no relationship between female body size (curve carapace length) and time invested in nesting (Kendall-Tau b=-0.068, p=0.41). Nevertheless, if we analyze these results considering the different phases, bigger females invest less time in excavating the egg chamber (Kendall-Tau b=-0.188, p=0.02).

## DISCUSSION

General nesting behavior of *Caretta caretta* in Boavista is very similar to that already described in precedent works on this species,

especially based in exhaustive description of behavioral patterns of nesting loggerheads made by Hailman & Elowson (1992).

Figure 1. Map showing Cape Verde Islands, and the position of Boavista.

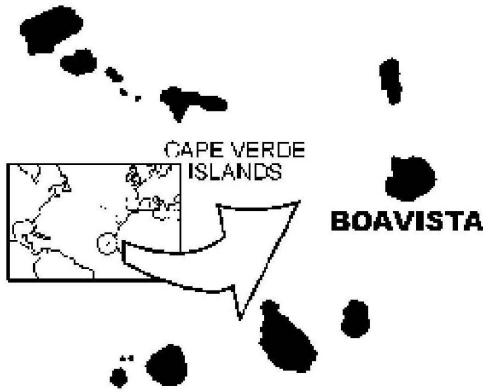
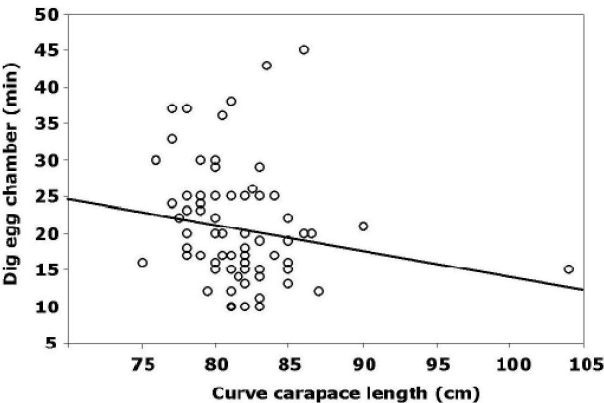


Table 1. Comparison of percentage of succesful nesting between populations.

Locality	Years	Successful nesting	Range
Turkey (Erk'akan, 1993)	1989	25.7%	
Australia (Limpus, 1985)		100%	
Florida (Raymond, 1984)			51-54%
South Carolina (Talbert et al., 1980)	1972-1976	59.5%	52.3-71.3%
South Carolina (Andre and West, 1981)		29%	
North Carolina (Crouse, 1984)		50%	
South Africa (Hughes et al., 1967)		55%	
Greece (Margaritoulis, 1982)	1977-1979	?	?
Boavista, Cape Verde	2000	44.27%	

Figure 2. Relationship between body size (CCL) and time for digging egg chamber on *Caretta caretta* from boavista.



The percentage of successful nesting (44.2%) is similar to the described ranges in other populations, which is in general variable. These data have been described to range normally between 30% and 70% (TABLE I), with the exception of Queensland (Australia), where almost all emergences recorded are successful nestings (Limpus, 1985). Possibly, the beach characteristics play an important role in this result, which might account for the difference found between our three beaches studied, especially Calheta (67.5%).

If we consider the total duration of nesting (67.4 minutes) and the different phases, the results are similar to those found in other populations (Kaufmann, 1973; Bustard et al., 1975; Dodd Jr, 1988), bearing in mind that the nesting time sensu stricto is considered, as in Hailman & Elowson (1992).

It is noteworthy that bigger females require less time to dig the chamber. It may be hypothesized that smaller females are more 'inexperienced'; according to Hailman & Elowson (1992), this is the most complex phase of those that constitute the nesting behavior of *Caretta caretta*.

Acknowledgements:

We thank the David and Lucile Packard Foundation and Sea Turtle Symposium for travel support.

LITERATURE CITED

Andre, J. D. & West, L. (1981). Nesting and management of the Atlantic loggerhead *Caretta caretta* (Linnaeus)(Testudines: Cheloniidae) on the Cape Islands, South Carolina, in 1979. *Brimleyana*, 6:73-82.

Bustard, H. R., Greenham, P. & Limpus, C. (1975). Nesting behavior of loggerhead and flatback turtles in Queensland, Australia. *Proc. K. Ned. Akad. Wet., Ser. C Biol. Med. Sci.*, 78(2):111-122.

Carr, A. (1982). Notes on the behavioral ecology of sea turtles, pp. 19-26. In K. A. Bjorndal (eds.), *Biology and Conservation of Sea Turtles*. Smithsonian Institution Press, Washington, D. C.

Crouse, D. T. (1984). Loggerhead sea turtle nesting in North Carolina: applications of an aerial survey. *Biological Conservation*, 29:143-155.

Dodd Jr, C. K. (1988). Synopsis of the Biological Data on the Loggerhead Sea Turtle *Caretta caretta* (Linnaeus 1758). Fish and Wildlife Service, U. S. Department of the Interior, Washington, DC.

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

Hailman, J. P. & Elowson, M. (1992). Ethogram of the nesting female loggerhead (*Caretta caretta*). *Herpetologica*, 48(1):1-30.

Hendrickson, J. R. (1995). Nesting behavior of sea turtles with emphasis on physical and behavioral determinants of nesting success or failure, pp. 53-57. In K. A. Bjorndal (eds.), *Biology and Conservation of Sea Turtles*. Smithsonian Institution Press, Washington, D. C.

Hughes, G. R., Bass, A. J. & Mentis, M. T. (1967). Further studies on marine turtles in Tongaland, I. *Lammergeyer*, 7:5-54.

Kaufmann, R. (1973). Biología de las tortugas marinas *Caretta caretta* y *Dermochelys coriacea*, de la costa Atlántica colombiana. *Acad. Colombiana Cienc. Exactas, Físicas y Nat.*, 14(54):67-80.

Limpus, C. J. (1985). A study of the loggerhead sea turtle, *Caretta caretta*, in Eastern Australia. Santa Lucia, Australia.

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

Miller, J. D. (1997). Reproduction in sea turtles, pp. 51-81. In P. L. Lutz and J. A. Musick (eds.), *The biology of sea turtles*. CRC Press, Boca Raton, Florida.

Raymond, P. W. (1984). The effects of beach restoration on marine turtles nesting in South Brevard County, Florida. Orlando, Florida.

Talbert, O. R., Stancyk, S. E. J., Dean, J. M. & Will, J. M. (1980). Nesting activity of the loggerhead turtle (*Caretta caretta*) in South Carolina. I: a rookery in transition. *Copeia*, 1980:709-719.

## A GIS APPROACH TO ASSESSING THE SPATIAL AND TEMPORAL RELATIONSHIP BETWEEN KEMP'S RIDLEY SEA TURTLES AND BLUE CRABS

Tasha L. Metz and André M. Landry, Jr.

Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, Texas 77843, USA

The blue crab (*Callinectes sapidus*), a preferred prey of the Kemp's ridley sea turtle (*Lepidochelys kempii*), has experienced recent population declines along the Texas coast. Concerns have arisen as to the impact of these declines on Kemp's ridley use of Texas waters as feeding and development grounds. This study employs GIS technology to examine the relationship between Kemp's ridley and blue crab abundance in shallow Gulf waters near Sabine Pass, Texas, an index habitat for the latter species, during 1993-2000. Seasonal occurrence and abundance (expressed as catch-per-unit-effort, CPUE) of Kemp's ridleys were assessed via monthly entanglement netting operations. Similar statistics were generated for blue crabs captured in otter trawls towed adjacent to netting sites. Elevated ridley CPUEs occurred concurrently with highly variable fluctuations in annual blue crab abundance from 1993-1997. Regression analysis of these catch statistics yields no strong logarithmic correlation between Kemp's ridley and blue crab abundance ( $r^2=0.07$ ). During these years, other factors including density dependent variables related to nesting success and a possible 2-3 year cyclic pattern in recruitment to benthic habitat may have influenced ridley aggregation on developmental feeding grounds. Peak ridley and blue crab abundances in 1997 were followed by

concurrent reductions in CPUE of both populations during 1998-2000. These trends yielded a strong logarithmic correlation between ridley and blue crab abundance from 1997-2000 ( $r^2=0.85$ ). The greater abundance of ridleys and blue crab on the west side of Sabine Pass ( $p = 0.01$ ,  $a = 0.05$ ) may be attributed to water vortices created by long shore currents and prevailing southerly winds at this site. Sediment deposition in this entrained water mass produces soft, muddy substrates characteristic of prime blue crab foraging grounds. Factors possibly influencing the decline in blue crab abundance, such as changes in salinity due to prolonged drought conditions, and their impact on Kemp's ridley dynamics are also assessed. Mean annual salinity levels failed to differ significantly across sampling sites ( $p = 0.62$ ,  $a = 0.05$ ), nor correlate statistically with Kemp's ridley and blue crab abundances (ridleys:  $r^2=0.01$ , crabs:  $r^2=0.40$ ). The influence of salinity on ridley or blue crab abundance may be masked by the annual analysis conducted in this study. In order to better understand and manage this endangered species, it is recommended that future research assess how overharvesting of blue crab, nesting beach dynamics, and shrimping activity/bycatch influence Kemp's ridley aggregation to developmental feeding grounds.

## NESTING OF THE HAWKSBILL TURTLE (*ERETMOCHELYS IMBRICATA*) IN DOCE LEGUAS KEYS, CUBA

Félix Moncada, Gonzalo Nodarse, Elvira Carrillo, Erich Escobar, and Elsa Morales

Centro de Investigaciones Pesqueras, Ministerio de Industria Pesquera, Barlovento, La Habana, Cuba

### INTRODUCTION

The Hawksbill turtle, *Eretmochelys imbricata*, is distributed throughout the Cuban archipelago. The main nesting areas for the species are off the south coast, the most important of which are in the Doce Leguas Keys. Doce Leguas Keys extend some 120 km, and are located within the Jardines de la Reina Archipelago (Archipelago of the Queen's Gardens), off the southeastern coast (Camaguey Province) of Cuba. They consist of 47 keys, of which more than 40% are sandy beaches used for nesting by the Hawksbill turtle, Green turtle (*Chelonia mydas*), and to a lesser degree the Loggerhead turtle (*Caretta caretta*). The remainder of the keys consist of mangroves and rocky coasts, and are unsuitable for nesting.

Most of the keys are small, between 0.5 and 5.5 km in length, and are separated by channels. The beaches are mainly medium grain

sand (0.2-2 mm diameter), but others are large grain sandy beaches mixed with coral, shells and stones. Most contain vegetation, mainly native bushes such as yana (*Conocarpus erecta*), yaraguano (*Coccothrinax miraguana*), pataban (*Laguncularia racemosa*), salvia marina (*Tournefortia anaphalodes*), platanillo (*Piper aduncum*), and grass and creeping shrubs like beach boniato (*Batis maritima*).

Beach slopes are slight (approximately 8 degrees) along most of their length, with a mean height of 1.1 m above sea level. Length of beaches ranges from 50 to 4000 m, with most being up to 25 m (mean= 9 m) wide. They present an oceanic front with ample coral barriers, more remarkable in the western part of the keys, which delimit an internal area of shallow waters between the coast and the barrier, where juvenile hawksbill turtles are abundant. Banks *Thalassia testudinum* and patches of *Syringodium* sp. on sandy bottoms are also abundant. Water depth is generally shallow.