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Nesting of the Hawksbill Turtle, *Eretmochelys imbicata*, at Río Lagartos, Yucatán, Mexico, 1990–1997

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ABSTRACT. – **One of the major hawksbill turtle (*Eretmochelys imbricata*) nesting colonies in the North Atlantic is located in the northeastern Yucatán Peninsula, Mexico. During 1990 to 1997 the nesting season extended from April to August, peaking in late May and the first weeks of June. The internesting period mode was 14 to 16 days. Remigration occurred most frequently at 2-year intervals (66.2%) and less often at 3-year intervals (19.9%). The highest percentage (44.8%) of remigrant females was recorded in 1997. Between 1.6 to 2.7 nests per turtle per season were laid (mean = 2.1), with most laying a single nest during all years. Mean nesting density was 8.6 nests/km with a range of 6.8 (1990) to 10.5 (1995). Oviposition frequency was highest in the open mid-beach area, above the tide berm edge amid sparse salt-resistant shrubs. Intra- and inter-annual nest site fidelity were very high, with most returns in a range of less than 3 km.**

KEY WORDS. – **Reptilia; Testudines; Cheloniidae; *Eretmochelys imbricata*; sea turtle; reproduction; nesting; nesting season; clutch frequency; Yucatán Peninsula; Mexico**

The Yucatán Peninsula is considered one of the most important hawksbill (*Eretmochelys imbricata*) nesting areas in the North Atlantic, and probably in the world (Meylan, 1989; Márquez, 1990). The peninsula is divided into three states, Campeche, Yucatán, and Quintana Roo. Five marine turtle species nest on the peninsula, most abundant among them being the hawksbill turtle which nests mainly in Campeche and Yucatán, the green turtle (*Chelonia mydas*) which nests throughout the peninsula, and the loggerhead (*Caretta caretta*) which nests primarily in Quintana Roo. There have also been sporadic instances of the leatherback (*Dermochelys coriacea*) nesting in Yucatán and Quintana Roo (*pers. obs.*) and Kemp´s ridley (*Lepidochelys kempii*) nesting in Campeche (Escanero et al., 1993).

There are several marine turtle conservation programs on the Yucatán Peninsula. Three of the oldest are: 1) Isla Mujeres, Quintana Roo, active since 1973, which deals with green turtles, loggerheads, and hawkbills, 2) Isla Aguada, Campeche, and 3) Río Lagartos, Yucatán, the last two active since 1979 (Sumano et al., 1980; Castañeda, 1987), both focusing primarily on hawkbills, though green turtles also have nesting grounds at these locations (Fig. 1). Presently, there are dozens of programs on the peninsula under the direction of government and non-governmental organizations.

One of the oldest turtle research stations is located at Las Coloradas, Río Lagartos, Yucatán, and is administrated by the National Fisheries Institute (INP, CRIP Yucalpetén), as part of the Secretariat of the Environment, Natural Resources and Fisheries (SEMARNAP). Research at this station, where the present study was conducted, concentrates on both nesting females on the beach as well as juveniles on foraging grounds.

This study addresses: 1) the spatial and temporal distribution of nesting, and 2) the results of tagging nesting females, including data on internesting period, distance between nests, clutch frequency, and female morphometrics.

METHODS

Study Site. — Located in the Reserva Especial de la Biosfera de Río Lagartos in the northeastern Yucatán Peninsula (Fig. 1), the study area consists of a 22 km long beach area east of the Las Coloradas salt factory. The beach is a sand bar forming a barrier between the open sea of the Gulf of Mexico and the hypersaline coastal lagoon of Río Lagartos. To the east of the Las Coloradas study area is the contiguous, 33 km long, El Cuyo turtle research station area, and even further east is the important nesting area of Isla Holbox, both administered by Pronatura Peninsula de Yucatán. West of the study area is the Reserve core, a 22 km long area, less important for turtle nesting, to which human access is limited.

Survey. — The study area was marked at 500 m intervals along its length and divided into 4 beach zones: 1) the tide wash zone; 2) the open mid-beach zone, above the tide berm edge, with or with out sparse salt-resistant shrubs; 3) the dune zone; and 4) the post-dune zone, including sites far behind the dune. The area was patrolled nightly, two passes per night, between 2000 hrs and 0600 hrs, using 4-wheel all-terrain-vehicles. Surveys consisted of searching for turtles and turtle tracks in the sand. When a turtle track was encountered, it was followed until a nest and/or turtle was found, or it became clear that it was a false crawl. Turtles were tagged with monel tags in both front flippers. Also, beginning in 1994, a hole was drilled in the trailing edge of the postcentral scutes of each turtle, and beginning in 1996

colored plastic strips were fastened to the marking holes. Measurements taken for each turtle included the standard straight carapace length (SCL) measured with a caliper and the standard curve carapace length (CCL) taken with a flexible measuring tape. The date, time, beach zone, and location relative to the 500 m markers from Las Coloradas, were recorded.

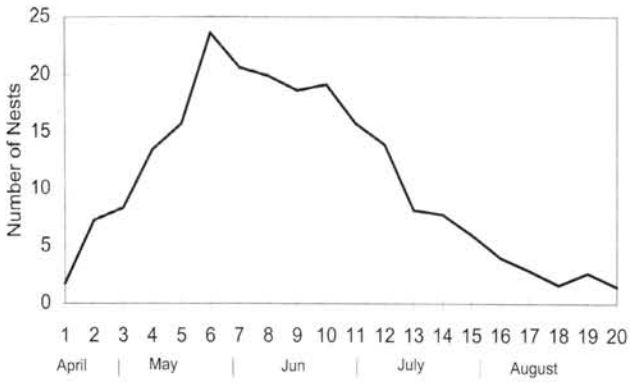
Data were collected and processed in various categories, as seen in Table 1, which reflect conditions encountered during the study. There are two categories for identified females, the overall category of Total Identified Females, which includes all females encountered, nesting or not, and the subcategory of Females Witnessed Nesting, which includes only those females encountered when nesting. Equally, there are two categories for observed nests, the overall category of Total Observed Nests, which includes all nests observed within the 22 km study area, and the subcategory of only those nests observed with an identified nesting female.

RESULTS

Distribution of intra-season nesting activity was similar throughout the 8-year study period. The 5 to 6-month seasons began in April with occasional nesting and some false crawls. The false crawls diminished and successful nesting increased during May, peaking during the last two weeks of May and the first half of June. Nesting then steadily decreased from mid-June, concluding with only occasional nesting during the last days of August and first days of September (Fig. 2).

The intra-annual internesting period followed a defined nesting pattern, approximately two weeks passing between one oviposition and the next (Fig. 3). The highest frequencies ranged from 14 to 16 days, though a 30 to 36-day mode was also recorded that may correspond to turtles for which an intermediate oviposition was not recorded. The highest frequencies were slightly elevated in 1996 and 1997, ranging from 19 to 21 days.

The number of nests per turtle per season was calculated using the number of tagged females and total nests recorded each year (Table 1), producing values ranging from 1.6 to 2.7, with a mean of 2.1 ± 0.4 nests/female/season. Turtles



during 1990–97 at Las Coloradas, Yucatán, México.

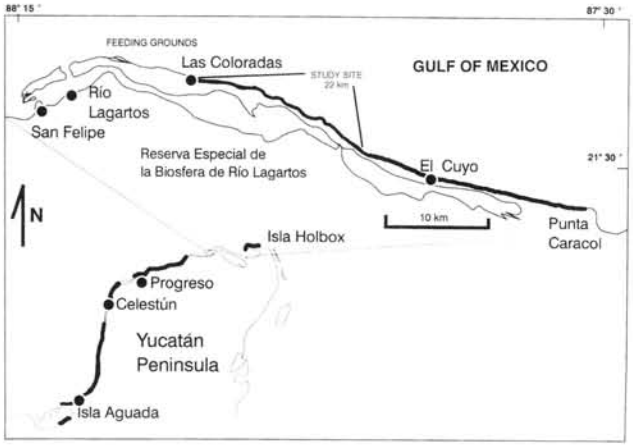


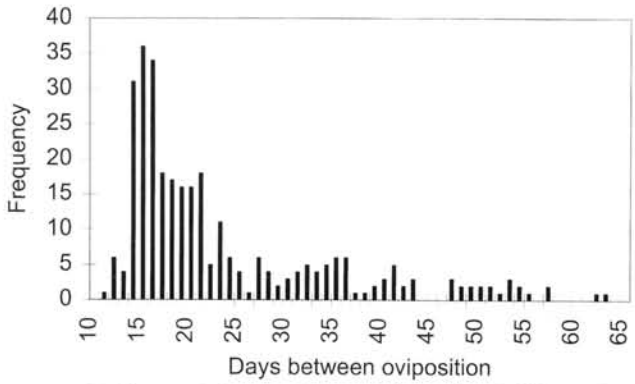
Figure 1. Hawksbill nesting beaches on the Yucatán Peninsula, México. The Reserva Especial de la Biosfera de Río Lagartos is enlarged. Towns are marked with dots, nesting beaches with a thick black line. The 22 km study site is also indicated.

producing a single nest predominated throughout the study period, but each year the number of turtles producing more than one nest increased (Table 2).

From a total of 151 observed remigration intervals the most common is every 2 years (66.2%, $n = 100$), followed by 3 years (19.9%, $n = 30$) (Fig. 4). Some uncertainty exists about turtles that were recorded every 4 or 5 years, as they may have remigrated within 2 or 3 years but were not observed at that time. The number of previously tagged remigrant females recorded increased yearly, and represented a higher percentage of the total number of recorded turtles each year, with a peak of 44% in 1997 (Table 3).

Within the study area, mean nesting density was 8.6 ± 1.5 nests/km, with a range of 6.8 ± 4.8 in 1990 to 10.5 ± 6.9 in 1995 (Table 4). Density was highest between kilometers 3 and 10, with a mean density of 11.8 ± 3.3 nests/km; range = 9.8 ± 7.9 nests/km (1990) – 15.0 ± 5.0 nests/km (1996) (Fig. 5). The lowest density was in an area modified by Hurricane Gilbert, between kilometers 11 and 16, with a mean of 5.7 ± 0.9 nests/km. In the area between kilometers 17 and 22, an important green turtle nesting area, mean hawksbill nest density was 7.7 ± 1.9 nests/km.

For the period 1991–97 oviposition frequency was highest (60.3%) in the open mid-beach zone, above the tide



gure 3. Observed internesting periods for hawksbills at Las Coloradas during the 1990–97 seasons.

Table 1. Summary of hawksbill nests laid and tagging results at Las Coloradas. Total Identified Females is all the females that were tagged, No. Females Witnessed Nesting represents turtles tagged that laid a nest. Nests/Female/Season is the Total Nests Registered divided by the Total Identified Females each season.

	1991	1992	1993	1994	1995	1996	1997
Total Identified Females	84	58	90	90	147	157	105
No. Females Witnessed Nesting	70	50	73	76	136	107	94
Total Nests Registered	186	158	189	201	232	244	247
Nests With Identified Females	110	82	120	116	195	167	167
% Nests With Identified Females	59	52	63	58	84	68	68
Nests/Female/Season	2.2	2.7	2.1	2.2	1.6	1.6	2.4

Table 2. Observed clutch frequency for hawksbills nesting at Las Coloradas, during the 1991–97 seasons.

Number of Nests	1991	1992	1993	1994	1995	1996	1997
1	40	30	41	48	95	63	50
2	21	11	22	21	26	30	25
3	8	6	6	6	12	12	12
4	1	3	3	1	3	2	4
5			1				3

berm edge, with or without sparse salt-resistant shrubs, followed by the dune zone (34.1%), the tide wash zone (1.1%), and the posterior dune zone (4.5%) (Fig. 6).

The highest frequency of nest site fidelity for within-season nesting ranged from 0 to 2.0 km, with a maximum recorded distance of 20 km (Fig. 7). From one season to the next, the highest frequency range was only slightly wider, from 0 up to 3.0 km. Some remigrant turtles have been recorded as far away as Isla Holbox, 80 km east.

Female carapace length frequencies for the two recording periods of 1985–87 and 1994 are shown in Fig. 8. The size ranges overlap between 89 cm to 103 cm SCL, with a mode of 95 cm. Some size extremes were recorded in 1985–87, with a minimum length of 75 cm and a maximum length of 113 cm, though no turtles were recorded in these size ranges from 1990–97.

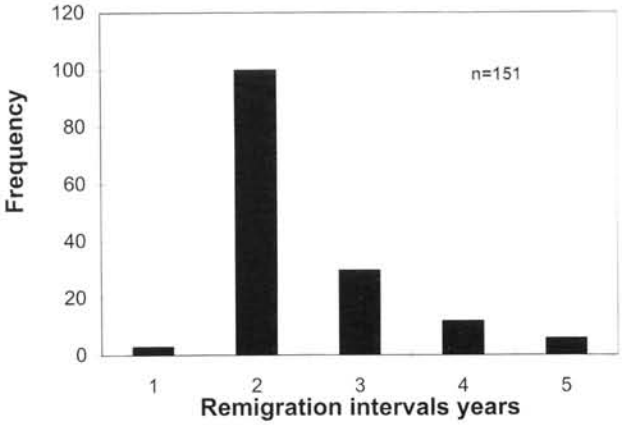


Figure 4. Observed remigration frequency of 151 hawksbills at Las Coloradas. Only 3 individuals were recorded at a 1-year interval.

DISCUSSION

Some uncertainty exists in interpretation of results for this study as the Las Coloradas area is only part of the wider hawksbill nesting area in the northeast Yucatán Peninsula. Differences through the years in research goals, resources, and personnel between Las Coloradas and El Cuyo do not permit consistency in analysis for the overall area. This mainly affected tagging policy and female identification criteria, but had little effect on nest registration. Also, survey effort within the Reserve core, between Las Coloradas and the town of Río Lagartos (Fig. 1), was of lesser intensity since the presence of turtle nesting activity was known to be lower in this area.

In spite of the variability and uncertainty of the data, nest site fidelity data indicate that only moderate exchange occurs between research areas. For instance, in 1993 when the tagging effort at both Las Coloradas and El Cuyo stations was equally high, a total of 147 turtles were tagged; 49.6%

Table 3. Summary of hawksbill tagging and recaptured remigrants at Las Coloradas during the 1985–97 seasons.

	Year of Tagging with Number of Tagged Females													Recaptures
Year of Recapture	1985 18	1986 37	1987 15	1988 n.d.	1989 2	1990 86	1991 84	1992 58	1993 90	1994 90	1995 147	1996 157	1997 105	Total %
1990	0	0	1 6.7%	0	0									1 1.1%
1991	2 11.1%	0	1 6.7%	3	0	0								6 7.1%
1992	0	0	0	0	0	14 16.3%	1 1.2%							15 25.9%
1993	0	0	0	0	0	8 9.3%	19 22.7%	0						27 30.0%
1994	0	0	0	0	0	5 5.8%	3 3.5%	14 24.2%	0					22 24.4%
1995	0	0	1 6.7%	0	0	3 3.4%	7 8.3%	7 12.1%	25 27.8%	0				43 35.4%
1996						1 1.1%	2 2.4%	8 13.8%	9 10.0%	25 27.8%	2 1.4%			47 29.9%
1997						3 3.4%	0	1 1.7%	15 16.7%	5 5.6%	23 15.6%	0		47 44.8%

Table 4. Mean hawksbill density nesting at Las Coloradas, during the 1990-97 seasons.

Year	Average Density/km	± S.D.
1990	7.2	6.7
1991	7.0	5.1
1992	6.8	4.8
1993	8.2	4.8
1994	8.9	4.4
1995	10.5	6.9
1996	10.2	6.1
1997	10.0	4.4
All years	8.6	1.5

were recorded only at Las Coloradas, 37.4% only at El Cuyo, and 12.9% were recorded at both stations. Data from the following years is inconsistent as tagging efforts were comparatively lower at stations such as El Cuyo and Isla Holbox. Additionally, no turtles tagged at distant stations with active tagging programs, such as those in Campeche, have been identified at Las Coloradas, and neither have turtles tagged at Las Coloradas been identified at these distant stations.

In some cases, nesting events were probably not recorded for turtles observed more than once in a season. Given an analysis of observation dates, it becomes apparent that a turtle could have nested between observations. For example, if a turtle was recorded 1 May and 1 June, it is quite possible it also nested in mid-May but was not observed. Analysis shows that that the estimated number of nests assigned to identified turtles is close to the total observed nests in the area during most of the study years, although in 1995 and 1996, these estimates exceeded the total number of observed nests, indicating that turtles tagged at Las Coloradas could be responsible for nests outside the study area. The possibility must also be taken into account that unidentified turtles may be responsible for some unwitnessed nestings, although it is assumed that almost all turtles coming to Las Coloradas, at least since 1995, were tagged.

Although a great number of female turtles have been tagged, many have still been observed without tags (56% in 1997). This may be due to a number of reasons. Tags may have fallen off turtles without leaving scars, some turtles may have escaped being tagged, others may come from areas where tagging is infrequent or nonexistent, and still others

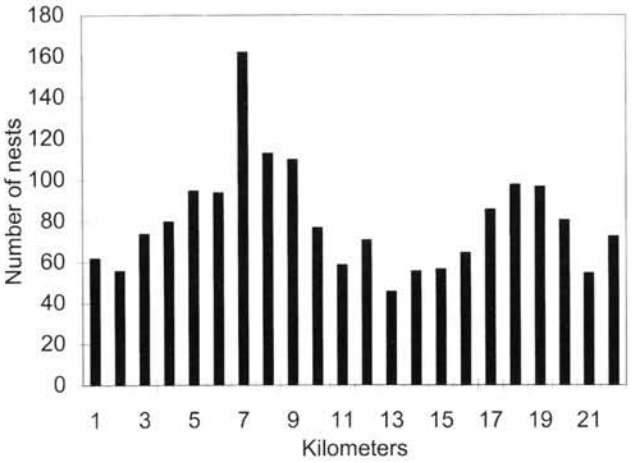


Figure 5. Distribution of hawksbill turtles observed along Las Coloradas nesting beach during the 1990–97 seasons.

may be recently matured neophytes. Marking with a hole in the postcentral scutes should better enable researchers to determine when turtles have lost flipper tags, and help in the estimation of mortality and recruitment.

The number of registered nests at the El Cuyo station was higher and more variable than that for the Las Coloradas station. Registered nests at El Cuyo increased from 67 in 1990 (Vázquez, 1993), an obvious underestimation, to 581 in 1995 (Campos et al., 1995), an 867% increase. During a comparable time period at Las Coloradas the total nests increased by 32.8%, from 186 in 1991 to 247 in 1997 (Table 1).

Overall nest density at El Cuyo was greater than at Las Coloradas (e.g., 17.6 and 10.5 nests/km, respectively, during 1995), even though the highest density recorded during 1996 at Las Coloradas between kilometers 3 and 10 (15.0 nests/km) was comparable to that at El Cuyo. This discrepancy may be due to two factors. The first is that the area between kilometers 11 and 16 at Las Coloradas was severely damaged by Hurricane Gilbert, making it a disturbed and possibly less than ideal nesting area. The second is that relatively dense green turtle nesting activity in the area between kilometers 18 and 22 may have caused competition for space between the two species, lowering hawksbill nest density.

As regards nest distribution within beach zones, results from the present study support Horrocks and Scott's (1991) idea that hawksbill turtles look for a compromise between

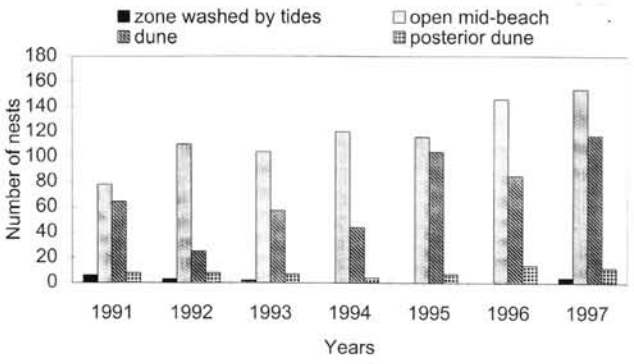


Figure 6. Distribution of nesting across 4 beach zones by hawksbill turtles at Las Coloradas during the 1991–97 seasons.

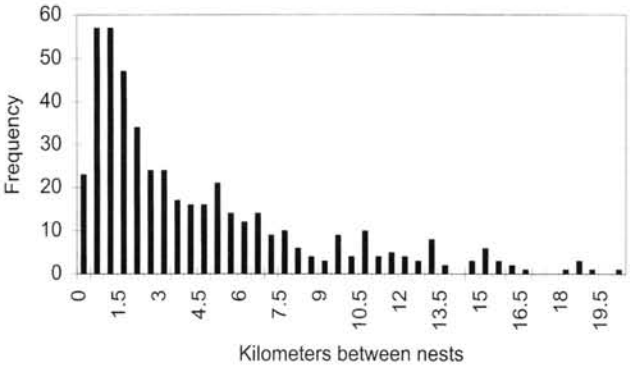


Figure 7. Intra-annual nest site fidelity of hawksbills at Las Coloradas, during the 1990–97 seasons.

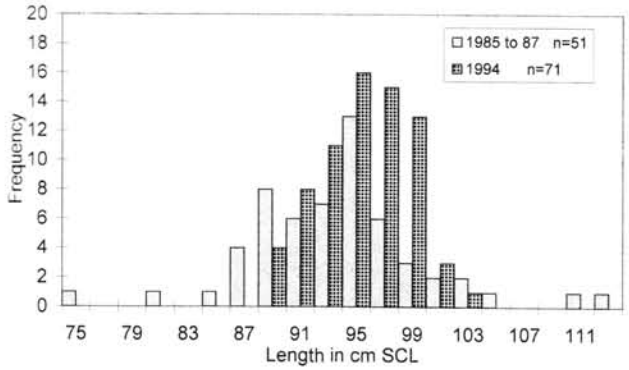


Figure 8. Carapace length (SCL) frequency of nesting hawksbills recorded in two separate periods, 1985–87 and 1994.

berm or beach height and distance from shore. This compromise directly affects hatchling survival prospects as nests too close to the tide zone risk being flooded, and those too far away result in excess hatchling energy expenditure and increased exposure to predation. Study area beaches varied in width. Turtles nesting in areas with wide mid-beach zones rarely reached the dune zone, and turtles nesting in areas with narrow mid-beach zones easily reached the dune zone, but very few went beyond into the posterior dune zone. Additionally, turtles exhibited no vegetation preference.

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