

# NESTING ECOLOGY OF THE OLIVE RIDLEY SEA TURTLE (*Lepidochelys olivacea*) (CHELONIIDAE) AT EL VALLE BEACH, NORTHERN PACIFIC, COLOMBIA

## Ecología de anidación de la tortuga golfina (*Lepidochelys olivacea*) (Cheloniidae) en la Playa El Valle, Pacífico Norte, Colombia

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### ABSTRACT

The olive ridley (*Lepidochelys olivacea*) is the most common sea turtle to nest in Colombia. El Valle beach is considered the most important nesting beach for this species in South America. Intensive direct capture of nesting females and egg poaching for consumption and local commercial purposes has been a common practice for years. We conducted an analysis of the nesting ecology of the olive ridley on El Valle beach in the northern Pacific of Colombia in 2008. A total of 164 clutches were transferred to an artificial hatchery for protection. The peak of nesting occurred from the second half of August until the end of September, accounting for 64.6 % of all nests. Along the beach, the section most frequently used was Section 3, with 26 % of the nests. The nests were laid mainly in zone 3.69 %. We encountered 55 nesting females and marked 46 of them. Mean CCL was  $64.9 \pm 2.4$  cm and mean CCW was  $68.6 \pm 2.6$  cm. Females laid on average of  $87.3 \pm 14.2$  eggs per clutch. We recorded two nesting events per female, with a mean inter-nesting period of  $18.8 \pm 4.2$  days. The reproductive output for the season was  $181.5 \pm 34.8$  eggs / female. Mean hatching success was  $81.1 \pm 12.1$  % and mean emergence success was  $77.6 \pm 12.7$  %. The incubation period was  $65 \pm 4.7$  days. Our study is a valuable contribution to knowledge of the reproductive ecology of the olive ridley population regionally and globally.

**Keywords:** conservation, Eastern Pacific Ocean, emergence success, hatching success, turtle rookery.

### RESUMEN

En Colombia, la tortuga golfina (*Lepidochelys olivacea*) es la más común de las tortugas anidantes. La playa El Valle es considerada la más importante para anidación en Suramérica. La intensa captura de hembras y saqueo de huevos para consumo y comercio local ha sido una práctica común por años. Realizamos un análisis de la ecología de anidación de la tortuga golfina en la Playa El Valle, Pacífico Norte, durante la temporada de 2008. Un total de 164 nidadas fueron transferidas a viveros de protección. El pico de anidación ocurrió durante la segunda quincena de agosto y septiembre con un 64,63 % de las posturas. A lo largo de la playa, el sector 3 presentó la mayor frecuencia de anidación con 26 %. Los nidos fueron desovados principalmente en la zona 3, con 69 %. Encontramos 55 hembras y 46 fueron marcadas. El LCC fue (promedio  $\pm$  DE:  $64,9 \pm 2,4$  cm) y ACC fue

(promedio  $\pm$  DE: 68,6  $\pm$  2,6 cm). Las hembras desovaron 87,3  $\pm$  14,2 huevos por nidada. Registramos dos eventos de anidación por hembra, con un intervalo de (promedio  $\pm$  DE: 18,8  $\pm$  4,2 días). El producto reproductivo fue (promedio  $\pm$  DE: 181,5  $\pm$  34,8 huevos por hembra). El promedio en éxito de eclosión fue 81,1  $\pm$  12,1 % y de emergencia 77,6  $\pm$  12,7 %. El período de incubación fue (promedio  $\pm$  DE: 65  $\pm$  4,7 días). Nuestros datos son una valiosa contribución al conocimiento de la ecología reproductiva de la población de tortugas golfinia regional y globalmente.

**Palabras clave:** colonia anidante, conservación, éxito de eclosión, éxito de emergencia, Océano Pacífico oriental.

## INTRODUCTION

The olive ridley sea turtle (*Lepidochelys olivacea*) is considered the most abundant sea turtle species in the eastern Pacific Ocean (EPO), and probably in the world (Márquez, 1990; Pritchard, 1997; Marcovaldi, 2001). The species is distributed in tropical and subtropical waters worldwide. It is found regularly in the Indian and Pacific Oceans (Márquez, 1990; Pritchard and Plotkin, 1995) and also in the South Atlantic (Reichart, 1993; Fretey, 2001). Recently, Eguchi *et al.*, (2007), using shipboard observations, estimated the at-sea population to number more than six million turtles in the EPO. At present, the species is categorized as vulnerable on the IUCN Red List (IUCN, 2013).

In the EPO rookery, the nesting distribution ranges from beaches in southern Mexico to Peru (Pritchard and Plotkin, 1995; Márquez *et al.*, 1996; Spotila, 2004; Wester *et al.*, 2011) and foraging individuals are found from California to Peru and Chile (Pritchard and Plotkin, 1995). Most of the EPO nesting sites support solitary nesters and receive small numbers of turtles, but in a few nesting beaches, including Mexico (La Escobilla and Morro Ayuta), Nicaragua (Playa Chacocente and Playa La Flor) and Costa Rica (Playa Ostional and Playa Nancite), the turtles nest in "arribadas", characterized by large numbers of females nesting synchronously on the beach (Pritchard and Plotkin, 1995; Márquez *et al.*, 1996; Valverde and Gates, 1999; Chaves *et al.*, 2005).

The nesting of the species in the southeastern Pacific is low-density compared to other EPO nesting sites. In Colombia, nesting has been reported as solitary (Ceballos-Fonseca *et al.*, 2003) and as rare in Ecuador and Peru, which is the southern boundary for olive ridley nesting (Hays-Brown and Brown, 1982; Manrique *et al.*, 2003; Álava *et al.*, 2007; Kelez *et al.*, 2009; Wester *et al.*, 2011).

In the Pacific of Colombia, the olive ridley is the most commonly nesting sea turtle. The principal nesting sites (more than 100 turtles/beach/year) are El Valle, (northern Pacific) (Ceballos-Fonseca *et al.*, 2003; Barrientos and Ramírez, 2008) and the Sanquianga Natural National Park, Amarales, Mulatos and Vigía (southern Pacific) (Amerocho *et al.*, 1992). In addition, approximately 30 other beaches

are used by olive ridleys for nesting in Colombia (Amerocho *et al.*, 1992; Ceballos-Fonseca *et al.*, 2003).

The El Valle beach is considered the most important nesting beach for olive ridleys in Colombia, and in South America (Martínez and Páez, 2000; Hinestroza and Páez, 2001; Barrientos and Ramírez, 2008). Monitoring of nesting female turtles occurs during the nesting season from July to December. The Fundación Natura (an NGO) and college students conducted systematic monitoring surveys from 1991 to 1999. Since 1991, a hatchery has been protecting nests and releasing hatchlings into the population. In 1990, this hatchery was initiated at the San Pichi Beach in the Utría Natural National Park but was transferred in 1991 to the El Valle beach. In the 1991 nesting season, 88 arrivals of olive ridley turtles were recorded on the beach, from which 56 females were marked, of which six renested. In 1992, 148 females were registered, and in 1993 30 other turtles were registered while nesting, and 47 nests were transferred. In 1994, there was an increase to 69 turtles registered on the beach, with 174 nests; in 1995, 46 turtles and 116 nests were recorded, and in 1996, 36 turtles and 128 nests were recorded. In 1998, 113 turtles were encountered on the beach and 91 nests were transferred to the hatchery facility, with a total of 8918 eggs. In the 1999, season there were 377 females recorded and 165 nests transferred (Martínez and Páez, 2000; Hinestroza and Páez, 2001).

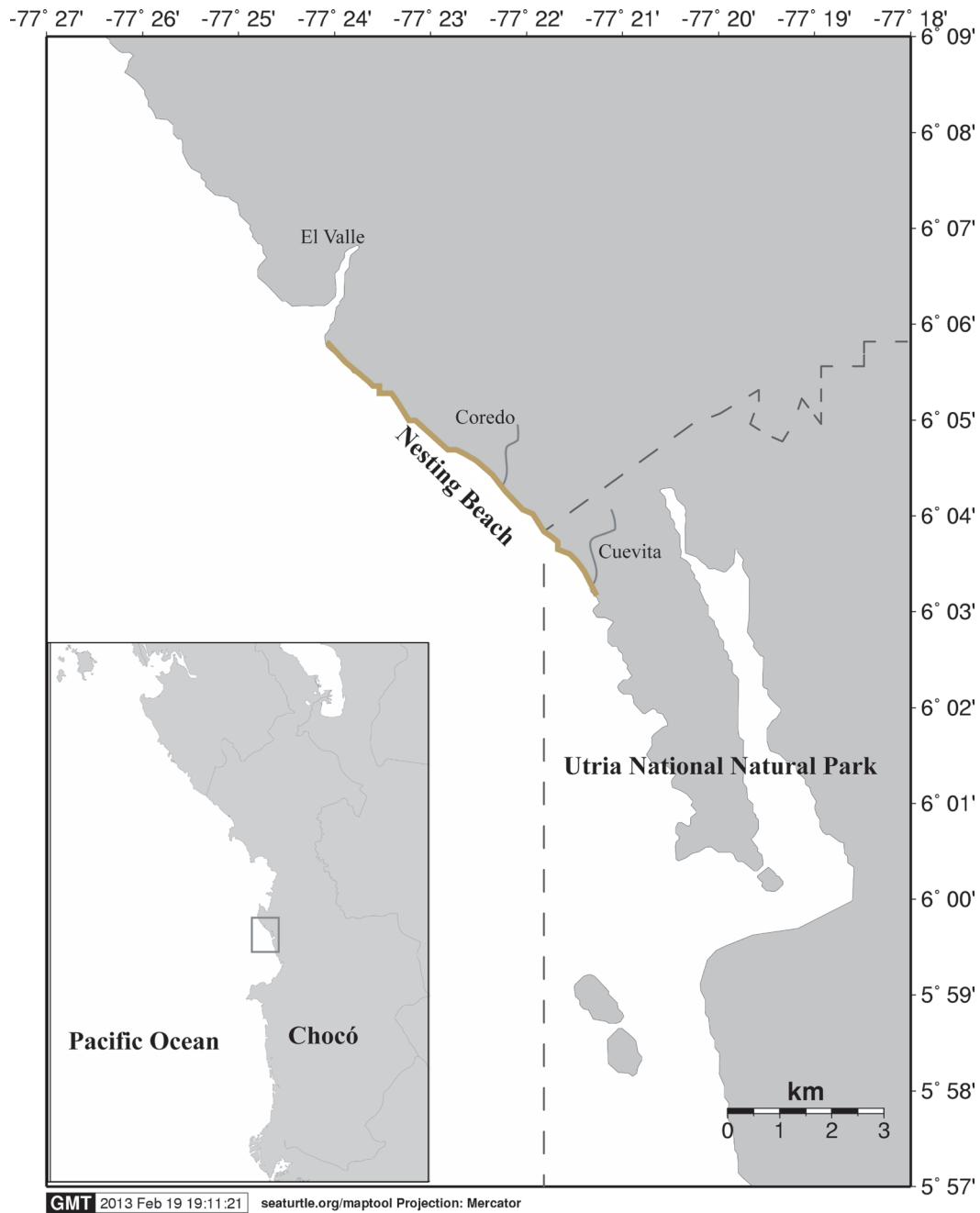
Monitoring ceased in 1999, until 2008 when beach monitoring was resumed with the help of local researchers (Aspropaclu), the support of the community council of El Cedro, and the Fundación Natura, which hosted nightly patrols to tag nesting females and to transfer clutches to the hatchery. This was deemed necessary because intensive direct capture of nesting females and egg poaching for consumption and/or local sale by communities located close to the El Valle beach has been a common practice for years (Ceballos-Fonseca *et al.*, 2003; Barrientos and Ramírez, 2008; Ramírez and Barrientos, 2012).

Here, we report an analysis of the nesting ecology of the olive ridleys on the El Valle beach, northern Colombian Pacific, during the entire 2008 nesting season. We estimated reproductive output, inter-nesting intervals, nesting and hatching success, and we describe the nesting process for this population. Finally, we assessed the importance of the El Valle beach as an olive ridley nesting site in the EPO, but the data are insufficient to establish population trends.

## MATERIALS AND METHODS

### Study site

The El Valle Beach (6°04'21, 00"N, 77°24'04, 62"W) is located on the northern Pacific coast of the Chocó region in Colombia (Fig. 1). The site is 8200-m-long (Barrientos and Ramírez, 2008), and a portion of the beach lies within the Utría Natural National Park (PNNU) (Fig. 1). This area has



**Figure 1.** Location of the study site in the northern Pacific coast of Colombia. The location of El Valle nesting beach and Utria National Natural Park are indicated (adapted from Barrientos *et al.*, 2013)

been inhabited by Afro Colombian people for over 100 years. The beach is interrupted by three permanent water bodies: the El Valle river and two streams: La Cuevita and Coredó. It is a high-energy beach that is exposed and receives strong waves (Martínez and Páez, 2000). The tides are semidiurnal with a range that can exceed 4 m, forming offshore currents that can attain high speeds (close to 2 m / s) during times of high tide (Prahl *et al.*, 1990).

### Nesting activity

To determine spatial use by olive ridleys, the beach was divided into nine sections along its south to north axis. First eight sections of 1000-m and in sub-sectors of 200-m and a final section of 200-m long. We distinguished three horizontal zones from the water to the vegetation: Zone 1 (the inter-tidal zone, that lies below the high water mark), Zone 2 (the mid-zone, located above the high tide

line) and Zone 3 (beginning where dune vegetation began and continuing to the back of the beach delimited by the presence of trees, grass, and creeping vegetation).

The El Valle beach was monitored both nightly and during morning surveys during the entire 2008 nesting season (July 20 to December 28). During this period, we patrolled the beach at night between 20:00 and 05:00, and all turtles encountered were tagged, measured and all nesting events were recorded. In the morning, between 6:00 and 9:00, we counted tracks to account for turtles that were missed the previous night and verified successful nesting events.

### Nesting turtles

When we encountered a turtle, we recorded its activity as: emerging from the ocean, digging a body pit, digging an egg chamber, laying eggs, covering the nest, or returning to the water. We recorded the nesting status of each turtle encountered (or tracks seen when the turtle was missed) as (1) a false crawl if no nest was encountered, or (2) a nesting event if there was evidence the turtle had laid eggs.

After the turtles finished laying eggs, all four flippers were checked for external tags. If a tag was present, the tag number was recorded. But if the turtle was not tagged, we marked it with a two Inconel 625 metal tags on the right and left front flippers after egg laying had finished. We tagged all turtles following the methodology presented in the Research and Management Techniques for the Conservation of Sea Turtles (Eckert *et al.*, 1999). For each turtle, we measured the curved carapace length (CCL) and curved carapace width (CCW) with a flexible measuring tape ( $\pm 0.05$  cm). We counted eggs with a mechanical counter during egg laying, or at the time of relocation of the clutch to the hatchery for protection. We estimated the reproductive output for nesting season of each individual by multiplying the average number of eggs per clutch by the number of confirmed nests of each female.

### Nest and hatcheries

We relocated all clutches to safer areas of the beach immediately after laying. In total, three hatchery areas were used for protecting the clutches during the incubation period, all of them located within the *Estación Septiembre* facility belonging to the *Fundación Natura*. We relocated eggs from nesting turtles we observed directly, or from other nests detected during the morning monitoring (less than six hours old), following standard protocols (see Chacón *et al.*, 2007). Eggs were placed in plastic garbage bags (5 l) and reburied in hatchery sand.

After 45 days of incubation, we checked each nest eight times a day to inspect for evidence of hatchling emergence. Five days after the first signs of emergence were observed, a subset of the nests was excavated to determine hatching success. At excavation, we counted the number of shells and classified unhatched eggs into four developmental categories

(Chacón *et al.*, 2007). We estimated hatching success using the formula  $H$  (Hatching) =  $S / (S+U) * 100$ , where  $S$  is the number of empty shells encountered (>50 % complete),  $U$  is the number of unhatched eggs. We estimated emergence success using the formula  $E$  (Emergence) =  $S - (L+D) / (S+U) * 100$ , where  $L$  is the number of live hatchlings found in the nest, and  $D$  is the number of dead hatchlings that managed to first leave their egg shells (Miller, 1999). Hatchlings found alive were released in the evening in the company of members of the El Valle community.

### Threats

Local threats to this species and other sea turtle species in the area were recorded.

### Statistical analyses

All statistical analyses were conducted using the statistical software package R, version 3.0.1 (R Development Core Team, 2013). We analyzed normality of the CCL distributions with the Shapiro-Wilks test. We used ANOVA tests and linear regressions to analyze the relationships between female size variables (CCL and CCW) and to analyze the effect of female size on clutch size. Differences in the number of eggs among clutches laid by the same female were inspected with Paired t-tests.

## RESULTS

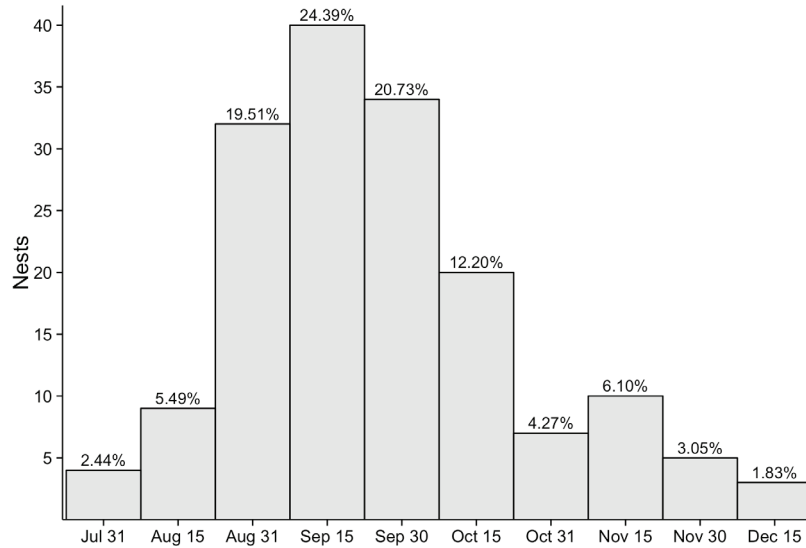
### Nesting activity

During the five months (July 20 to December 28, 2008), a total of 164 clutches were transferred to the hatchery, with a total of 176 successful nests laid and 202 female arrivals recorded. The peak of the nesting period ranged from the second half of August to the end of September (64.6 % of all nests, Fig. 2). The most active time for nesting was between 21:01- 22:00 hr.

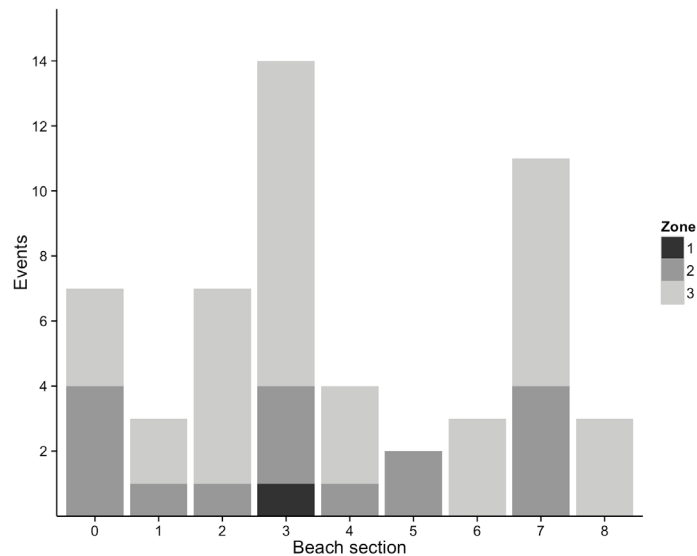
The beach sections most frequently used were Sections 3 and 7, with 26 % and 20 % of nests laid, respectively (Fig. 3). We determined that over half of the nests were laid in Zone 3 (69 %), while in Zone 1 and 2, 2 % and 30 % of all nests were laid, respectively (Fig. 3).

### Nesting females and nests

At the El Valle beach, we encountered 55 nesting female olive ridleys and tagged 46 them with two Inconel metal tags on the front flippers after they had laid. The size of the females (CCL) was normally distributed during this season ( $W = 0.99$ ,  $p = 0.79$ , Fig. 4). The CCL for turtles was (mean  $\pm$  SD)  $64.9 \pm 2.4$  cm (range 9.2 – 70.5 a 59.2 – 70.5 y n = a), and the CCW was  $68.6 \pm 2.6$  cm (range 63.5 – 75.0 a 63.5 – 75.0 y n = a). In olive ridleys the typical pattern is for the carapace to be wider than is long. Therefore, for the following analysis we discarded one female with an atypical carapace: 66.8 cm CCL and 66.4 cm CCW. A strong correlation ( $r = 0.83$ ) was found between the CCL and CCW ( $r^2 = 0.681$ , ANOVA,



**Figure 2.** Temporal distribution of *L. olivacea* nesting at El Valle beach, Choco. Number of nests ( $n = 164$ ) per two week periods during the 2008 season.



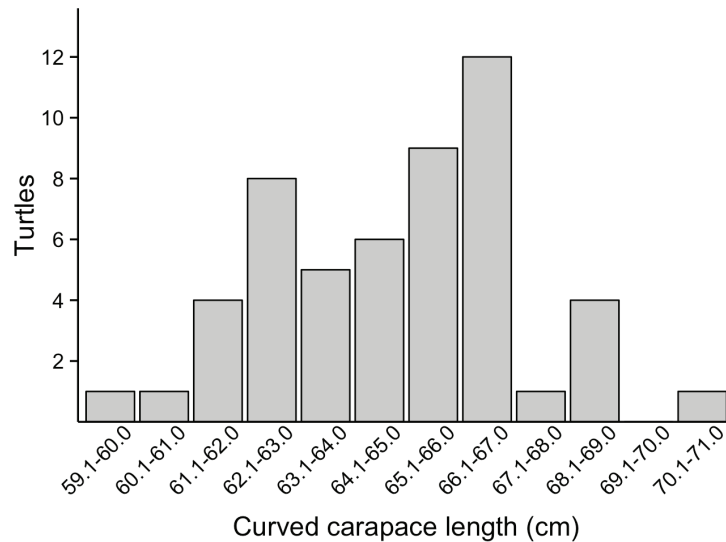
**Figure 3.** Spatial distribution of *L. olivacea* nests at El Valle beach, Choco. The x-axis sections 0-7 are 1000-m-wide beach sectors along the north-south axis of the beach (\*section 8 is a 200-m-wide sector). In each section, nests were laid in three horizontal zones, 1: below high tide line, 2: between high tide line and the vegetation line, and 3: in the vegetation on the dune. Numbers of nests ( $n = 54$ ) identified during 2008 season.

$F(1, 46 \text{ df}) = 98.18; p < 0.001$ ). The females laid on average  $87.3 \pm 14.2$  yolked eggs per clutch ( $n = 46$ ). We recorded a maximum of two nesting events per female, with an inter-nesting period of (mean  $\pm$  SD)  $18.8 \pm 4.2$  days (range 16 – 25 days;  $n = 4$ ). These turtles tended to lay smaller clutch the second time, although the differences were not significant ( $t = 2.9 \text{ df} = 6, p = 0.063$ ).

The estimated reproductive output for the season was (mean  $\pm$  SD)  $181.5 \pm 34.8$  eggs per female ( $n = 4$ ). Female CCL was

correlated with clutch size ( $r^2 = 0.101$ , ANOVA,  $F(1, 43 \text{ df}) = 4.83, p = 0.03$ ), but not significant relationship was found between CCW and clutch size (ANOVA,  $F(1, 43 \text{ df}) = 0.21; p = 0.6457$ ).

The mean hatching success from nests at the hatchery was  $81.1 \pm 12.1\%$  (range 45.8 – 100;  $n = 25$ ) and mean emergence success was  $77.6 \pm 12.7\%$  (range 45.8 – 93.4;  $n = 25$ ). The incubation period to emergence in the hatchery was (mean  $\pm$  SD)  $65 \pm 4.7$  days (range 54 – 73;  $n = 25$ ).



**Figure 4.** CCL frequency of female *L. olivacea* at El Valle beach, Choco, 2008 season (n = 52).

### Threats

We identified direct harvest of five olive ridley females and the poaching of 12 clutches by local people. This probably occurred early in the morning, between 4:00 – 6:00 hr, when patrol effort was lowest. We also recorded evidence of incidental by-catch in artisanal fisheries. Fishing gear such as long lines and gillnets are used in the waters off of the El Valle beach, a threat not only to the olive ridleys, but also for other species of sea turtles that feed there (e.g., the black turtle, *Chelonia mydas* and the hawksbill, *Eretmochelys imbricata*). During this project, one male olive ridley was harvested in the gill net of a local fisherman, who intended to consume it. However, project personnel alerted local authorities who confiscated and released this individual. Also a juvenile hawksbill was caught by in another gill net, but was returned voluntarily by its captor.

### DISCUSSION

We confirmed for this olive ridley rookery a peak in nesting activity during the second half of August until the end of September, with over 64 % of all nests laid during this period (Fig. 2), as was also documented during the 1999 nesting season (Hinestroza and Páez, 2001). Peak time for nesting was between 21:00 and 22:00 hr, which also agrees with Hinestroza and Páez (2001), who reported a peak in the number of arrivals between 21:00 – 23:00 hr. Therefore, the early hours of the night appears to be the time when most turtles emerge to nest. However, this result also may have been due to a higher effort by project staff to monitor at the beginning of the night.

A total of 52 % of all *L. olivacea* nests were located in beach sections 3 (26 %) and 7 - 8 (26 %) (Fig. 3). Section 3 borders the Coredo stream in section 4 and sections 7 - 8 border

the El Valle river, indicating some preference for nesting near river mouths (Pritchard and Mortimer, 2000), where broader sand platforms are formed, producing better conditions for the nesting (Amarocho, 1993). In contrast, in 1998 and 1999 most nesting occurred in the three first sectors of the beach, but these also are located near the Cuevita stream (Martínez and Páez, 2000; Hinestroza and Páez, 2001).

Nesting female olive ridleys usually selected flat, open and unobstructed areas and deposit their clutches between the high tide line and the vegetational line (Cornelius, 1976; Reina *et al.*, 2002). This behavior has been modified in some Colombian Pacific beaches, where females place their clutches between driftwood and the vegetation line, because the sand portion in this zone is almost completely inundated during high tides (Amarocho *et al.*, 1992). In this study of the El Valle beach, females also preferred to nest in the highest beach area, on the dune (69 %). However, in the past females tended to nest most in the lowest (Martínez and Páez, 2000) or mid level (Hinestroza and Páez, 2001) of this beach. This spatial distribution shift might have been the result of a local dynamic of gain and loss of sand on the beach profile, where serious erosion is occurring.

During the 2008 nesting season, a total of 55 females were encountered but only four (2.2 %) were intercepted a second time. This low rate of recapture may have been due to several factors: i) there may be a high percentage of older females at this rookery, who lack the reproductive ability to re-nest. This would reflect a demographic imbalance in the population that has resulted from a low rate of juvenile recruitment (Hirth, 1971; Rueda, 1992) due to the anthropogenic pressures this site has experienced over the years (e.g., harvest of reproductive females and eggs). Mark-recapture efforts conducted during the 1998 season also



only managed to document re-nesting in three females. ii) Females at the El Valle beach nest more than once, but do so in nearby beaches like the San Pichi beach, located south of the El Valle beach within the Utría Natural National Park. iii) Given the length of the beach and the extended time required to patrol it, some females may have been able to re-nest undetected. However, this seems unlikely, since over 12 people working each night insured extensive coverage of the entire beach over the 2008 nesting season.

The average CCL reported by Hinestroza and Páez (2001) was  $66 \pm 2.47$  cm, compared to  $64.9 \pm 2.4$  cm (range 59.2 – 70.5;  $n = 52$ ) in this study, and the average clutch size reported by Hinestroza and Páez (2001) was  $102 \pm 23.04$  eggs, compared to  $87 \pm 19.1$  eggs in this study. However, we feel more comparable data is needed from additional nesting seasons before it is possible to speculate that the anthropic pressures this rookery faces is producing a reduction in mean female size, and hence also mean clutch size. Low recapture rates between seasons also make it difficult to establish body growth rates for this population (Chaloupka and Musick, 1997).

The inter-nesting interval for olive ridley turtles is variable, but usually ranges between 14 to 28 days (Pritchard, 1969; Kalb and Owens, 1994; Plotkin, 1994), consistent with the 16 to 25 day intervals documented ( $n = 4$ ) documented at the El Valle beach rookery. Although Carr (1967) reported

that *C. mydas* lays fewer eggs in the first and last clutches each season, we observed a decrease in clutch size in the second clutch of all four re-nesting females, a trend also observed by Carr and Hirth (1962) and Pritchard (1971). However, we found that this reduction in the number of eggs per clutch was not significant.

We documented a significant relationship between clutch size and the CCL of nesting females. This pattern also occurs in green turtles (Carr and Hirth, 1962; Pritchard, 1969; Hirth, 1971) and loggerhead turtles (Ehrhart, 1995). Nevertheless, there was not a significant relationship between CCL and the total estimated reproductive output over the entire season, perhaps because of the small sample sizes this year.

There was a difference of 14 days in mean incubation periods between the 2008 and the 1999 seasons. We estimated hatching success at 81.1 % ( $\pm 12.1$ ), representing an increase of 14.1 % compared to 1997 (Vélez, 1997), a decrease of 0.4 % compared to 1998 (Martínez and Páez, 2000) and an increase of 9.7 % compared to 1999 (Hinestroza and Páez, 2001) (Table 1.). The main mortality during incubation occurred during the embryonic development stage (34.1 %). While all years enjoyed high hatching success rates, but it will be necessary in future nesting seasons at the El Valle beach to compare success rates of *in situ* and transferred nests, in order to make better informed management decisions for this species.

Season	Hatching success (%)	Emergence success (%)	Incubation length (d)	Source
1997	67	n.r	n.r	Vélez, 1997
1998	81.5	n.r	n.r	Martínez and Páez, 2000
1999	71.4 (304)	71.5 (304)	51 (5)	Hinestroza and Páez, 2001
2008	81.1 $\pm$ 12.1 (25)	77.6 $\pm$ 12.7 (25)	65 $\pm$ 4.7 (25)	Present study

**Table 1.** Summary of hatching success (%), emergence success (%) and incubation periods (days) (mean  $\pm$  SD and  $n$ ) of olive ridley (*Lepidochelys olivacea*) clutches laid at El Valle beach, Chocó, during several seasons. n.r. = not reported.

## CONCLUSIONS

Although the El Valle beach is considered one of the most important nesting sites in Pacific South America for *L. olivacea*, because of limited monitoring of nesting females, data are insufficient to establish population trends. Thus, the data obtained in this study is a valuable contribution to the knowledge of the reproductive ecology of the olive ridley regionally and globally, and hopefully will help refine on-going conservation actions. In 2008 we saw a substantial reduction in nest poaching by humans. According to data reporting from other seasons, when many females were harvested and poaching of nests approached 100 %, while in 2008 only five female turtles were consumed and egg poaching was only 2 % of all clutches. This demonstrates that continuous education efforts directed at members of the local community have

produced greater environmental awareness and that local communities are able to develop respect for sea turtles and help efforts directed towards their conservation.

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