Marine turtle nesting and conservation needs on the south-east coast of Nicaragua

Cynthia J. Lagueux and Cathi L. Campbell

Abstract The goal of this study was to quantify marine turtle nesting activity by species, identify threats to their populations, and provide recommendations for their conservation on the south-east coast of Nicaragua. One survey was conducted in each of 1998 and 1999, and 10 surveys in 2000. The majority of nesting emergences were by leatherback *Dermochelys coriacea* and hawksbill *Eretmochelys imbricata* turtles, with some nesting also by green turtles *Chelonia mydas*. In 2000, egg poaching was highest for green turtle (83%) and hawksbill (75%) clutches. A total of 87 dead stranded turtles were encountered, of which at least 63.2% were green, 10.3% hawksbill, and 6.9% loggerhead turtles. The principal threats to marine turtle populations on the south-east coast of Nicaragua were the killing of nesting females, egg poaching, and bycatch in commercial and artisanal fisheries.

Keywords Caribbean, *Chelonia mydas*, *Dermochelys coriacea*, El Cocal, *Eretmochelys imbricata*, marine turtle, nesting, Nicaragua, threats.

Introduction

There are seven extant species of marine turtles. Six are categorized on the IUCN Red List as Critically Endangered, Endangered or Threatened (IUCN, 2004) and listed on Appendix I of CITES (CITES, 2005). The Caribbean region provides important nesting, foraging, and developmental habitats for four species of marine turtles: green *Chelonia mydas*, hawksbill *Eretmochelys imbricata*, leatherback *Dermochelys coriacea* and loggerhead *Caretta caretta*. All of these species can be found in the shallow coastal and offshore waters of Caribbean Nicaragua, which has long been known for its large foraging aggregation of green turtles (Carr *et al.*, 1978).

Marine turtle nesting on the Caribbean coast of Nicaragua has been reported on the Pearl Cays (Nietschmann, 1981; Lagueux *et al.*, 2003) and at El Cocal (Pritchard, 1971; Nietschmann, 1973). The Pearl Cays are a group of 18 nearshore cays located off the central Caribbean coast where >150 hawksbill clutches are currently laid per year (Lagueux *et al.*, 2003). El Cocal is a mainland beach located on the south-east coast of Nicaragua where nesting levels, historical or current, have not been previously reported, and threats to nesting species have not been assessed.

In this study we provide results from surveys and informal interviews conducted at El Cocal over a 3-year period. Our objectives were to (1) determine the spatial and temporal distribution of nesting by species, (2) determine the threats to each population, and (3) provide recommendations for the conservation and recovery of turtle populations at this site.

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Methods

Study site and survey frequency

The beach along the south-east coast of Nicaragua is characterized by a complex rhythmic topography (Murray *et al.*, 1982) and dynamic black sand with high energy waves and is relatively wide, particularly in the vicinity of the mouth of the Río Indio/San Juan (Fig. 1). San Juan del Norte is located on the west bank of the Río Indio that runs parallel to the coast at this location, separating the town from the beach. In 1998 there were *c.* 600 people (including Creole, Mestizo and Rama Indians) residing in San Juan del Norte. Another six families resided at Cangrejera and/or Haulover. In an attempt to raise awareness about marine turtles we gave presentations and involved local inhabitants in conducting beach surveys.

Beach surveys were conducted from the mouth of Spanish Creek southward to the mouth of the Río Indio/San Juan, referred to here as El Cocal, a length of 26.3 km (Fig. 1), and from the mouth of the Río San Juanillo southward to the border with Costa Rica, referred to here as San Juanillo (Fig. 1). The beach was divided into four sections, from north to south: Spanish Creek to Haulover (SH, length 5.40 km), Haulover to Cangrejera (HC, length 10.71 km), Cangrejera to the mouth of the Río Indio/San Juan (CS, length 10.19 km), and from the mouth of the Río

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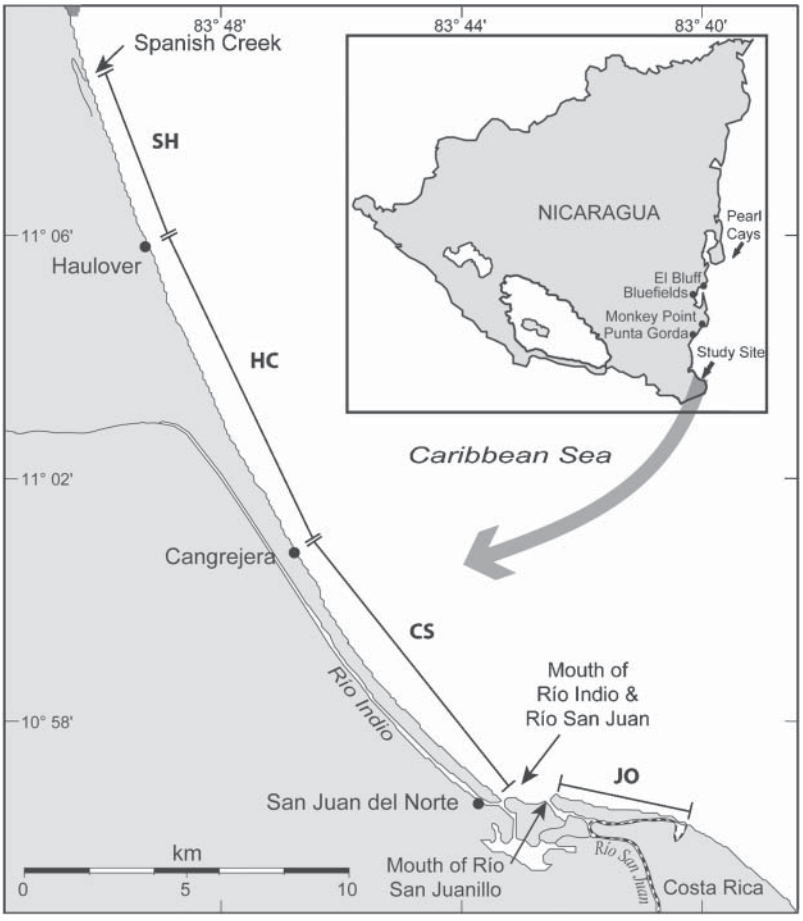

Fig. 1 Map of the study area and relevant locations along the south-east coast of Nicaragua. See Methods for a description of beach sections. This map has been modified from the original created with Maptool (Maptool, 2005).

San Juanillo to the border with Costa Rica (JO, length 2.85 km) (Fig. 1). Global Positioning System locations obtained in the field were used in Maptool (Maptool, 2005) to calculate the approximate length of each beach section.

Reconnaissance surveys were initiated on 30 July 1998 and 10 May 1999. In 2000, 10 surveys were conducted at approximately 3-week intervals from 15 April to 29 October, with the exceptions that the SH section was not walked during one survey and the JO section was surveyed only on 20 August.

Nesting beach and shrimp boat surveys

Nesting emergences were based on the presence of a well formed body pit and the characteristics of the nest site, e.g. the scatter of sand around the body pit resulting from camouflaging the site. A body pit is a depression on the beach surface left by the female after the nesting process. Both authors have extensive experience in distinguishing between nesting and non-nesting emergences of the turtle species that nest in the region. We recorded, and identified to species, nesting emergences, poached nests (for 2000 only) and marine turtle carcasses. Although a body pit does not guarantee a clutch was laid, logistical and time constraints prohibited us from confirming the presence of eggs. All recent nesting activity was recorded during the 1998 and 1999 surveys and in the first survey of 2000. For all subsequent surveys in 2000 all nesting activity since the previous survey was recorded. In 2000 we assumed we were able to observe all nesting activity. A clutch was recorded as poached when the nest cavity was found open and no eggs were present or egg shells were found in or near the nest cavity. To avoid double counting of nesting emergences during subsequent surveys flagging tape was tied to vegetation near the nest and the turtle track was crossed out in the sand. Skeletal remains and carcasses were identified to species whenever possible. In 2000 marine turtle carcasses and skeletal remains were spray-painted bright orange to avoid double counting. Minimum, over-the-curve carapace length (CCLmin) and sex of carcasses were recorded whenever possible. Carapace length was measured along the midline from the anterior edge of the nuchal scute to the junction of the supracaudals.

To evaluate the potential relationship between dead stranded turtles at El Cocal and shrimp trawling activity in 2000 we counted the number of shrimp boats offshore

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for each direction of travel between El Bluff and the mouth of the Río Indio/San Juan (Fig. 1). We were interested in this relationship because coastal inhabitants believed that the occurrence of stranded turtles was because of shrimp trawling. Using the higher of the two counts of shrimp boats, a Pearson Correlation was used to determine if there was a relationship between strandings and shrimp boats observed during the previous trip to the study area (*c.* 3–4 weeks earlier). We used shrimp boat counts from the previous beach survey because a time lag would be expected between drowning by shrimp trawling and beach stranding. We did not determine the time to strand, the trajectory of turtle strandings, or the proportion of turtle carcasses that strand when discarded from boats offshore. However, based on the direction of predominant currents dead turtles discarded between El Bluff and the mouth of the Río Indio/San Juan would probably strand south-west of the discard point, and potentially contribute to dead stranded turtles at El Cocal.

Results

Leatherback, hawksbill and green turtles were confirmed nesting and one loggerhead turtle nest was reported but could not be confirmed (Table 1). The majority of nesting of leatherback and green turtles occurred in the CS section and of hawksbills in the HC section (Table 2). In 2000 nesting density for leatherback turtles was highest in section CS (Table 3). Hawksbill nesting occurred at similar densities in the three northernmost sections. An equal number of green turtle nests were found in the JO and CS sections in 2000, although nesting density was almost 3.5 times higher in the JO section. No green turtle nesting was observed in the northernmost (SH) section during any of the 3 years (Table 2).

Leatherback nesting occurred from, at least, April to late-June with peak nesting in April and May (Fig. 2). Hawksbill nesting began by late-May and continued to the end of October, with relatively high nesting from late-July to September. Green turtle nesting occurred within the hawksbill nesting season.

In 2000 74.7% of hawksbill clutches and 83.3% of green turtle clutches were poached (Table 4). Of the hawksbill clutches poached, the majority (82%) were taken from the HC and CS sections. Little or no poaching of leatherback clutches occurred in any of the three sections where they nested. In 1999, however, 35.3% ($n = 12$) of leatherback nest sites showed signs of probing by humans.

A total of 87 dead stranded turtles were observed (Table 5). In addition, in 2000, one male green turtle carcass, with both rear flippers removed, was encountered offshore from Punta Raquel during our travel to the study site. In 1998 and 2000 the majority of turtles stranded, 57.8 and 73.7%, respectively, were green turtles. In 1999 only four turtles were encountered stranded dead. The only indication of a possible stranding by a leatherback was a humerus bone found on the beach in 1998. Peak strandings of green and hawksbill turtles occurred in July (Fig. 3). More than 67% of green turtle strandings occurred during an approximately 1-month period beginning the last week of June. Loggerhead strandings were encountered only at the beginning of the survey period (Fig. 3).

In 2000, based on information from local informants and our personal observations, a minimum of seven green, three hawksbill, and one loggerhead turtle were captured in artisanal lobster and gill-net fisheries and were killed and consumed in San Juan del Norte. In addition, carcasses from nesting females consumed by

Table 1 Number of nests of each marine turtle species at El Cocal and San Juanillo for all surveys conducted in 1998, 1999 and 2000.

Species	1998[1]	1999[1]	2000
Leatherback	1	34	72
Hawksbill	12	7	75
Green	10	1	6
Loggerhead	0	0	1[2]
Unidentified	7	10	2

[1]Only one survey was conducted and this is not therefore a complete nest count for the year.
[2]Nest was reported to us by a local resident but could not be confirmed.

Table 2 Number (%) of nests by species and beach section (Fig. 1, see text for details) at El Cocal and San Juanillo for all surveys conducted in 1998, 1999 and 2000 combined.

	Beach section (south to north)				
Species	JO	CS	HC	SH	Total
Leatherback	0	64 (59.8)	41 (38.3)	2 (1.9)	107
Hawksbill	1 (1.1)	33 (35.1)	45 (47.9)	15 (16.0)	94
Green	3 (17.6)	9 (52.9)	5 (29.4)	0	17
Loggerhead	0	0	1[1] (100)	0	1
Unidentified	2 (10.5)	12 (63.2)	4 (21.1)	1 (5.3)	19

[1]Nest was reported to us by a local resident but could not be confirmed.

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Table 3 Nesting density as nests per km (number of nests) by species and beach section (Fig. 1, see text for details) at El Cocal and San Juanillo from April to October 2000.

	Beach Section (south to north)				
Species	JO	CS	HC	SH	Average
Leatherback	0	4.12 (42)	2.61 (28)	0.37 (2)	2.74 (72)
Hawksbill	0.35 (1)	2.75 (28)	2.89 (31)	2.78 (15)	2.57 (75)
Green	1.05 (3)	0.29 (3)	0	0	0.46 (6)
Unidentified	0.7 (2)	0	0	0	0.7 (2)
Average by section	2.11 (6)	7.16 (73)	5.51 (59)	3.15 (17)	5.32 (155)

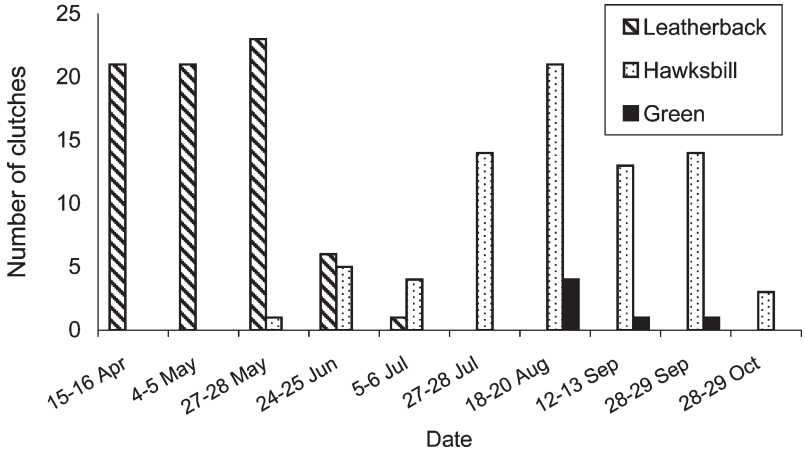

Fig. 2 Temporal distribution of marine turtle nesting activity at El Cocal and San Juanillo, Nicaragua, from 15 April to 29 October 2000. The 18–20 August survey also includes results from the additional survey conducted from the mouth of the Río San Juanillo to the Costa Rica border.

Table 4 Total number of clutches and number (%) poached of each species by beach section (Fig. 1, see text for details) at El Cocal and San Juanillo in 2000.

	Clutches in each beach section				Clutches (%) poached in each beach section			
Species	JO	CS	HC	SH	JO	CS	HC	SH
Leatherback	0	42	28	2	0	2 (4.8)	1 (3.6)	0
Hawksbill	1	28	31	15	1 (100)	23 (82.1)	23 (74.2)	9 (60)
Green	3	3	0	0	3 (100)	2 (66.7)	0	0
Unidentified	2	0	0	0	2 (100)	0	0	0

Table 5 Number of dead stranded marine turtles by species encountered on the beach from the Costa Rica border to the mouth of the Río San Juanillo and from the mouth of the Río Indio/San Juan to Spanish Creek, Nicaragua in 1998, 1999 and 2000.

Species	July/August 1998[1]	May 1999[1]	April–October 2000[2]	Total
Leatherback	1[3]	0	0	1
Hawksbill	1	3	5	9
Green	26	1	29[4]	56
Loggerhead	1	0	5	6
Unidentified	16	0	0	16
Total	45	4	39	88

[1]One survey conducted from the mouth of the Río Indio/San Juan to Spanish Creek.
[2]Ten surveys conducted from the mouth of the Río Indio/San Juan to Spanish Creek and one survey from the border with Costa Rica to the mouth of the San Juanillo.
[3]Based on a humerus bone encountered on the beach.
[4]Includes one large male encountered floating dead offshore from Punta Raquel, located between Bluefields and El Cocal.

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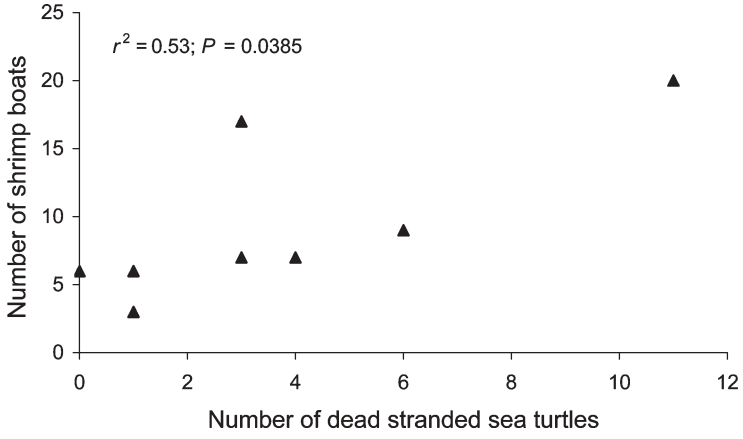

Fig. 3 Temporal distribution of stranded dead marine turtles encountered at El Cocal, Nicaragua, from 15 April to 29 October 2000.

local inhabitants were observed at Cangrejera and on the upper beach platform.

For all years combined mean CCLmin for stranded green turtles was 90.5 ± SE 2.9 cm (range 56.0–107.4 cm, $n = 20$), 81.6 ± SE 1.4 cm (range 78.1–88.6 cm, $n = 7$) for hawksbill, and 76.8 ± SE 4.9 cm (range 66.5–95.1 cm, $n = 5$) for loggerhead turtles (Fig. 4). Of the turtles for which sex could be determined, three green turtles were males and one was a female with several size classes of ovarian follicles present, and one hawksbill turtle was a male.

A total of 76 shrimp boats (mean 8.4 ± SE 2.1 shrimp boats per survey, range 1–20, $n = 9$ surveys) were observed offshore during travel between El Bluff and the mouth of the Río Indio/San Juan, a travel distance of *c.* 118 km. There was a significant positive correlation between the number of marine turtle carcasses encountered (most of which were intact or with flippers cleanly removed at the joint) during a survey and the number of shrimp boats observed trawling during the previous survey between El Bluff and the mouth of the Río Indio/San Juan (Fig. 5).

Discussion

A few decades ago El Cocal was probably an important site for nesting of hawksbill turtles. Two older, life-long residents of San Juan del Norte estimated, independently, that hawksbill nesting today is less than one-quarter of what it was in the 1970s. Nietschmann (1973) stated that El Cocal was the most important nesting beach for hawksbill turtles in Nicaragua, although today more than twice the number of clutches is laid per year further north in the Pearl Cays (Lagueux *et al.*, 2003). The cause for the decline of hawksbill turtles at El Cocal is, at least in part, because of the killing of nesting females, harvesting of eggs, and drowning in shrimp trawls and lobster and gill nets. Poaching of both hawksbill and green turtle clutches was high. Egg poaching did not appear to vary greatly between beach sections, although it was slightly higher in the south close to San Juan del Norte. Although not quantified, the opportunistic harvest of nesting females also frequently occurs.

Nesting of leatherback turtles occurs along the Caribbean coast of Central America from Honduras to Panama (Pritchard, 1971; Marin, 1984; Meylan *et al.*, 1985), but is

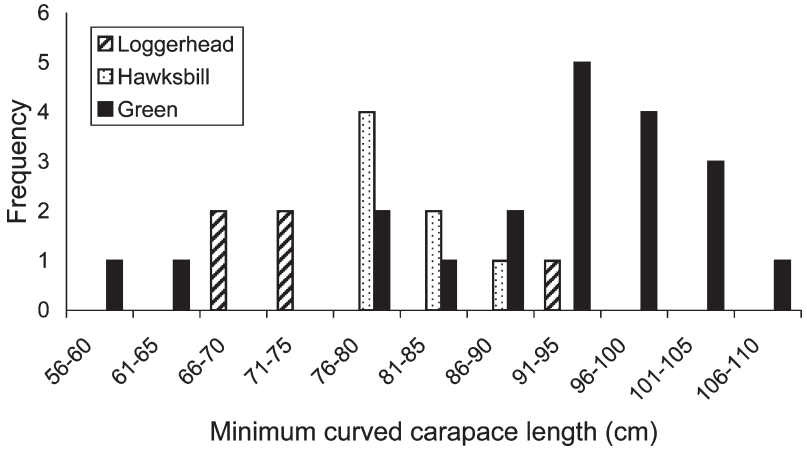

Fig. 4 Size distribution of stranded dead marine turtles on the beach at El Cocal, Nicaragua, based on a total of 12 surveys conducted in 1998 (n = 1), 1999 (n = 1) and 2000 (n = 10), combined. See Methods for a description of the carapace length measurement.

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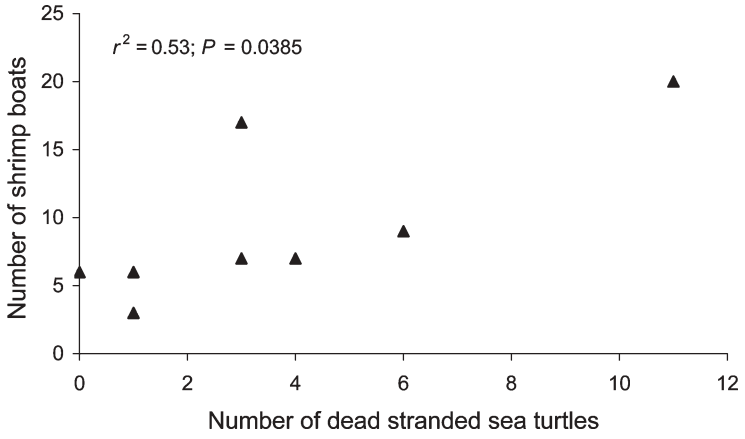

Fig. 5 Scatterplot of the number of dead stranded marine turtles encountered on the El Cocal beach during each survey and the number of shrimp boats observed between El Bluff and El Cocal for the previous survey in 2000, Nicaragua.

densest in Costa Rica (Campbell *et al.*, 1996; Leslie *et al.*, 1996; Chacón Chaverri, 1999). El Cocal is the only known nesting site of leatherback turtles in Caribbean Nicaragua, except for a report of hatchlings on the beach near the mouth of the Río Grande de Matagalpa (L. Churnside, pers. comm.). Because of the lower nest site fidelity demonstrated by leatherback turtle populations in general (Chacón Chaverri, 1999; Dutton *et al.*, 1999; Troëng *et al.*, 2004) those that nest at El Cocal are probably part of the Caribbean Costa Rica rookery. We have no evidence to indicate that nesting of leatherback turtles is declining. Overall, poaching of egg clutches was relatively low and there was little evidence of leatherback turtle mortality on the nesting beach. Local residents reported that leatherback turtle eggs were too difficult to find and thus they did not spend much time looking for them, which supports our findings in 2000. However, because we have no information about nesting levels of leatherback turtles at El Cocal prior to 1998 it is not possible to determine whether nesting levels have changed.

Two interviewees estimated, independently, that in May and June 1998 *c.* 200 turtles stranded dead within the study area. Although during our surveys we encountered fewer stranded turtles, additional carcasses were probably buried on the beach by sand accretion. The source of dead stranded turtles was not verified but, because the carcasses of recently dead turtles were nearly intact, they probably drowned in shrimp trawl nets. If the turtles had been killed in the local gill-net and lobster fisheries they would have been consumed by local inhabitants. There were no other fisheries that capture turtles in the area.

The significant correlation between turtle strandings and shrimp boats in the area 3–4 weeks prior to a survey suggests that shrimp trawling may be a significant source of mortality for turtles along the south-east coast of Nicaragua, and may also indicate that turtle excluder devices (TEDs) are not being used, as required by Nicaragua law, or are not functioning properly. The impact of shrimp trawling on marine turtle populations and the use of TEDs to mitigate the impact of the shrimp fishery are well documented (Pritchard & Márquez, 1973; Henwood & Stuntz, 1987; National Research Council, 1990; Crowder *et al.*, 1994; Lewison *et al.*, 2003). Positive correlations between stranded turtles and shrimping effort have also been reported for the Gulf of Mexico (Caillouet et al., 1991; Lewison *et al.*, 2003) and South Carolina (Crowder *et al.*, 1995).

The temporal distribution of marine turtle strandings is probably influenced by several factors, including (1) the density of turtles in the area, i.e. there are fewer hawksbill and green turtles earlier in the year because they have not yet migrated through the area or to the area to nest, (2) the extent of shrimp trawling activities throughout the year, and (3) marine turtle species are not affected equally by fishing activities.

Green turtles were the most frequently stranded species (63.6%) and were probably from the green turtle rookery in Tortuguero, Costa Rica, because of the proximity of El Cocal to Tortuguero and the nearby migratory corridor used by at least part of the reproductive population. Thousands of green turtles from the Tortuguero population are also taken each year in the Nicaragua artisanal green turtle fishery (Bass *et al.*, 1998; Lagueux, 1998). The low survival probabilities estimated by Campbell & Lagueux (2005) for Tortuguero adult females (0.82), and large juveniles and adults (0.55) tagged in Nicaragua are primarily because of industrial and artisanal fisheries in Nicaragua. As a result of these low survival probabilities the Tortuguero population is probably declining (Campbell, 2003).

Survivorship of large juvenile and adult life stages have the greatest effect on the population growth of marine turtles (Crowder *et al.*, 1994; Heppell *et al.*, 1996) and are the stages most heavily affected by fishing and poaching activities at El Cocal. When compared to the mean carapace length of nesting females (Carr & Hirth,

1962; Ehrhart & Yoder, 1978; Lagueux *et al.*, 2003) dead stranded hawksbill, loggerhead, and green turtles at El Cocal were all large juveniles or adults. Strong conservation measures are needed to reduce these threats and aid in the recovery of marine turtle populations in the region, and we make the following recommendations: (1) Evaluate the effect of lobster and gill-net fisheries on marine turtle populations, i.e., numbers captured and killed by species, size, sex, capture location, and seasonality. (2) Monitor nesting activity, at least weekly, and conduct nocturnal beach patrols, as often as possible from February to October. (3) Initiate an educational campaign amongst local coastal inhabitants, and employ local residents to conduct marine turtle conservation activities. (4) Implement a tag and release programme for turtles captured by local fishers. (5) Develop a paying volunteer programme to assist with and to defray the cost of conservation activities. (6) Establish no-net fishing zones in front of the beach during the nesting seasons.

Due to logistical constraints we have not been able to continue surveys at El Cocal, but we have provided our results to the community and government authorities and are optimistic that conservation measures can be implemented and enforced. In doing so, Nicaragua could become a significant contributor to regional and global marine turtle conservation, particularly for the Critically Endangered hawksbill turtle. In addition, we plan to initiate a monitoring and educational programme, which will involve the local community and coastal university students, to promote marine turtle conservation at El Cocal.

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Biographical sketches

Cynthia Lagueux has conducted research and worked on marine turtle conservation issues in Central America since 1981 and is a member of the IUCN Marine Turtle Specialist Group. Her research interests include studying the impact of human use on marine turtle populations.

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