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# Reproduction and conservation of the leatherback turtle *Dermochelys coriacea* (Testudines: Dermochelyidae) in Gandoca, Costa Rica

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**Abstract:** The leatherback turtle was studied in Gandoca, an important nesting beach on the southeastern Caribbean coast of Costa Rica (82° 37' W; 09° 37' N). In 1994, a total of 530 nests was recorded during the nesting season (February/July) and 160 leatherbacks were tagged; five were remigrants from the 1992 season and 15 carried tags from elsewhere. Eighty eight females only nested once. Mean curve carapace measurements were length 153.8 cm and width 112.0 cm. A hatchery received 82 clutches, with 6277 normal eggs. Their mean incubation period was 62.24 days (range: 56-68 days). Average hatching rate was 55.10% (S.D.: 25.04, range 15-96%). Extensive erosion, beach debris and poaching activity represent the main hazards for nesting in Gandoca.

**Key words:** Leatherback, nesting, hatchling, hatchery, Caribbean, Costa Rica.

The Gandoca/Manzanillo National Wildlife Refuge (GMNWR), encompasses 4,436 hectares of marine area, with dominance of hard bottoms (mainly coral and sands) (Yesaki & Giudicelli 1971). Three types of coastal communities are common: coral reefs (Cocles to Monkey Point), turtle and manatee seagrass beds, and mangrove swamps (Gandoca coastal lagoon), (Fig. 1).

Costa Rica's Gandoca Beach, extending 8.85 kilometers from Monkey Point to the southeastern corner of the country (The Sixaola River, boundary with Panama), has long been one of the country's least accessible beaches. It is also one of three major sea turtle beaches on the Caribbean coast of Costa Rica, providing nesting sites for all four species of sea turtles known from the Caribbean (green turtle, *Chelonia mydas*; Hawksbill turtle, *Eretmochelys imbricata*, loggerhead turtle, *Caretta caretta*, but especially the leatherback turtle or "baula", *Dermochelys coriacea* Vandelli, 1761, the largest of all sea turtles).

Gandoca Beach is a typical high-energy beach with a medium to steep slope and a crenate to dentate shoreline. The width of the berm varies from 0 to 20 m. The configuration

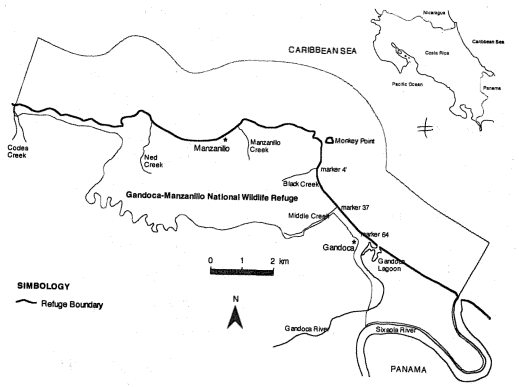


Fig. 1. Geographic distribution of nests on the beach in reference to markers.

of some parts of the berm and the height of the beach change over the course of the nesting and hatching seasons as a result of longshore currents, storm waves and high spring tides. In general, this beach has a poorly developed berm during much of the year and is partly covered by assorted debris including logs, coconut husks and a wide variety and amount of plastic articles, most of which originate on the banana farms in the Sixaola river watershed. The high

energy characteristics of this coast are associated with a narrow platform and prevailing strong currents moving in a southerly direction. Although the shores are mostly sandy, there has been a recent input of organic waste and terrigenous sediment due to human induced changes along the Atlantic lowlands, as a result of agricultural and tourist development. This sediment load is assumed to be responsible for the degradation of some reefs and seagrass beds and access to the beaches.

The leatherback turtle is now considered an "endangered species" throughout its distributional range; it is included in appendix I of CITES and the Red Data Book of the IUCN.

Goals of the study were to develop diagnostics for the beach and the berm condition (geomorphological and ecological), establish an artificial hatchery and locate natural nesting sites; prepare and carry out Rapid Ecological Assessments (REA) derived from the diagnostics to define safe and high risk nesting areas and record morphometric measurements of females and hatchlings.

## MATERIAL AND METHODS

Work began during the second week of February, 1994. The beach, from Monkey Point to the mouth of the Sixaola River, was divided into 50 meter segments to facilitate mapping of nests.

Each female encountered on the beach was marked after oviposition, with a metal tag. Tags were placed on the skin between the tail and the rear flippers, following the methodology proposed by Hirth and Ogren (1987).

For each adult encountered on the beach four measurements were taken according to the methodology established by Cornelius (1976), Pritchard *et al.* (1983), Hirth & Ogren (1987), Bjorndal & Carr (1989) and Guadamuz (in prep.).

All eggs confiscated from poachers by the refuge guards, plus clutches laid in high risk zones (within 100 meters of the mouth of Black Creek, Middle Creek, the Gandoca Lagoon and smaller temporary streams; near or below the high tide line in erosive zones) were relocated in the hatchery.

The hatchery was constructed on the berm of the beach between markers 54-55 (Fig. 2), and enclosed an area of 25 $m^2$. Eggs were placed in wire mesh cylinders to protect against predation by ghost crabs (*Ocypode* sp.) Eggs were buried at the same depths reported for natural nests.

Temperature was monitored in each nest three times daily (0600, 1200 and 1800 hours) as proposed by Witzell & Banner (1980).

Following emergence, the hatchlings were measured, weighed and then released. Nests were excavated to determine hatching success. Unhatched eggs were opened and classified following the criteria of Crastz (1982) and Whitmore & Dutton (1985).

## RESULTS AND DISCUSSION

A total of 530 clutches was laid on this beach between February 25 and July 15 1994; 160 leatherback females were tagged and measured. Nesting was most intense in the areas between markers 15 and 20, 31 and 39 and 64 and 69 (Fig.2). Gandoca beach is characterized by deep water close to shore, absence of fringing reefs (except around Monkey Point), and a high sloped beach which facilitates the landing of *D. coriacea*. The turtles frequently nest at or below the high water mark (HWM). Of the 530 clutches, 43% were laid on the upper berm, 41% above the high tide line and 16% below HWM; similar data was reported by Marquez (1990). Cartín (in prep.) reported that in Gandoca in 1991, 64% of the nests were located at or below HWM, with consequent high risk of loss. Eggs laid below the upper berm are

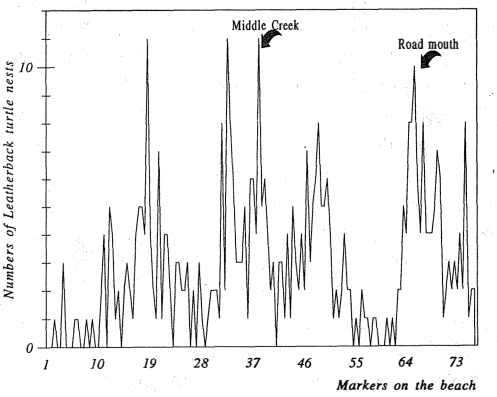


**Fig. 2. Nesting frequency and distribution on the beach.**

certainly subject to marine water seepage at high tide. Whitmore & Dutton (1985) have demonstrated that embryonic development is adversely affected by high concentrations of chloride, restricted gas exchange and excessive moisture.

The presence of 15 turtles with foreign tags (University of Florida and National Marine Fisheries Service of United States), demonstrates the irregularity of nesting beach selection by some turtles. These turtles were originally tagged at Matina, Costa Rica (M.T. Koberg, pers. comm), Playona Beach, Colombia (Rueda *et al.* 1992) or on the Caribbean coast of Panama, near Gandoca (Meylan *et al.* 1985). It is possible that some turtles lay eggs on Gandoca beach and then subsequently nest in Panama or Matina during the same year, or that remigrants may choose different nesting sites. This "scattered-nesting" behavior has been found in other rookeries of leatherbacks (Tucker 1990). Leatherbacks often nest in St. Croix and neighbouring islands around Puerto Rico during the same season (Dutton & McDonald, 1994).

This season five remigrants had been tagged originally in 1992 on Gandoca beach demonstrating a nesting cycle of 2 years. These turtles did not show renesting patterns in 1992 except turtle N° D7144-45, which was observed twice (4/14/92, 5/28/92); in 1994 every one of the turtles nested twice or more during the season.

Seventy-two of the leatherbacks recorded two or more times had renesting periods from 9 to 11 days, with a statistical mode of 10 days. This agrees with data reported by the National Research Council (1990) and Rueda *et al.* (1992), (Fig. 3). Chaves *et al.* (in prep.) reported a range of 7 to 11 days for renesting in Mondonguillo Reserve (Costa Rica Caribbean north coast) in 1994.

Other turtles presented a renesting period with irregular numbers of days. Some turtles visit Gandoca beach and return a second time three months later; possibly in their absence from Gandoca Beach they renest in Panama or on Costa Rica's northern Atlantic beaches.

Comparative analysis with data from 1990, 1991 and 1992 for Gandoca Beach (Venegas in prep., Cartín in prep., Quirós in prep.) shows that the most important months for nesting are

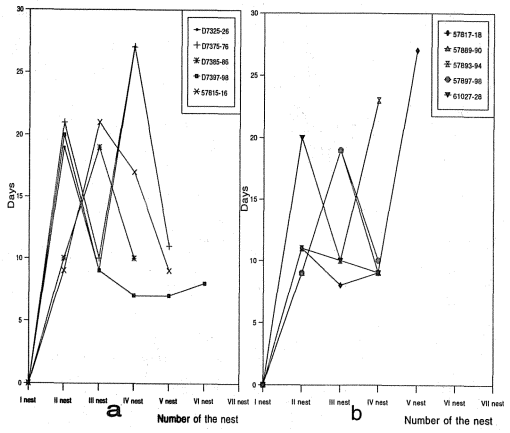


**Fig. 3. Renesting frequency** information for the leatherback sea turtle, Gandoca beach, Costa Rica, 1994 (numbers represent tag number)

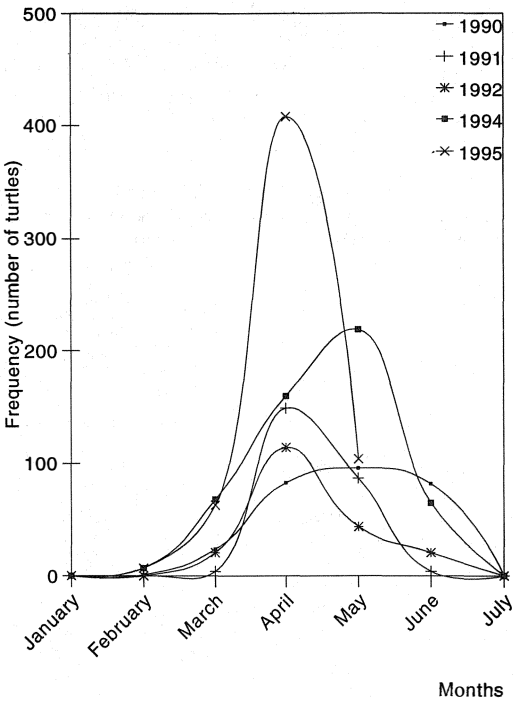


Fig. 4. Nesting on the beach during four different nesting seasons in Gandoca.

April and May (Fig. 4), which agrees with Pritchard (1971), Márquez (1990) and Rueda *et al.* (1992). The total number of nests on Gandoca beach for 1994 was 530 with a density of 12.8 nests/100 m of beach, and a mean of 5.12 turtles per night.

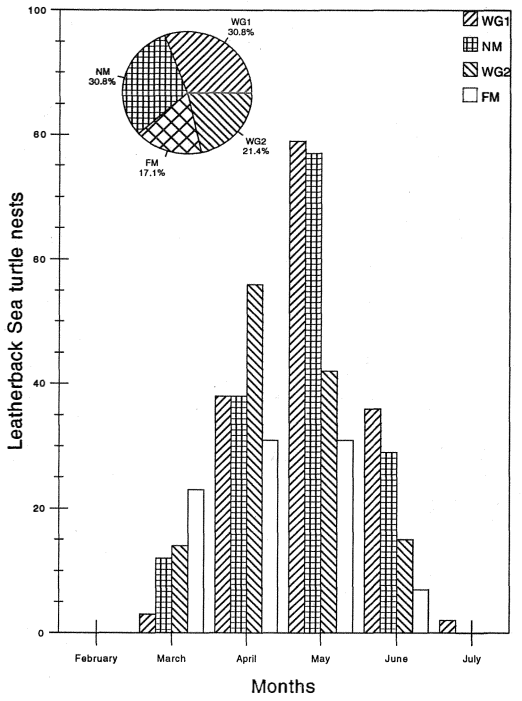


Fig. 5. Nesting frequency of the leatherback sea turtle in relation to moon phase (WG1: waning moon; WG2: waxing moon; NM: new moon; FM: full moon)

61.6% of the turtles emerged during dark moon phases (Fig. 5), supporting the selective behavior hypothesis in which turtles visit the beach on dark nights, a survival strategy to avoid high rates of predation.

Mean curve carapace length of 173 turtles measured this season was 153.8 cm, which is within the range reported by other investigators at Gandoca and other sites (Hirth & Ogren 1987, Chu 1990, Hall 1990, Cartín in prep., Quirós in prep., Rueda *et al.* 1992, McDonald *et al.* 1993, Chaves *et al.* in prep., Table 1). Mean curve carapace width was 112.0 cm (Standard Deviation S.D.: 10.37, range 92.0-177.0 cm), mean straight carapace length was 145.85 cm and the straight carapace width was 84.29 cm (Table 2). The curve carapace lengths are most commonly distributed within the 145.1-150.0 cm and 150.1-155.0 cm size ranges. These two classes together comprise 48.2% of the total turtles measured (Fig. 6).

Comparison of nesters among different rookeries is difficult but the possible existence of a leatherback metapopulation in the Caribbean comprising various rookeries is an important hypothesis to consider in comparing data from different rookeries.

Clutch size was determined for 248 nests on Gandoca beach. Mean number of normal

TABLE 1

*Comparison of curvature and standard carapace length of nesting females at Ganadoca beach with other Caribbean rokeries*

| | Puerto Rico[1] | Trinidad[2] | St. Croix[3] | CRCNC[4] | 1991[5] | 1992[6] | 1994[7] | 1994 |
|---|---|---|---|---|---|---|---|---|
| Curve carapace length (cm) | 155.3 | 157.6 | 152.56 | 152.8 | 153.5 | 153.3 | 154.3 | 153.8 |
| Range | 140.0-167.8 | 139.7-210.0 | 131.0-177.4 | 134.6-171.5 | 134.0-166.0 | 122.0-168.0 | 133.0-179.0 | 115.0-205.0 |
| S.D. | 6.6 | n.i. | n.i. | n.i. | n.i. | 7.7 | 7.32 | 10.4 |
| N | 42 | 104 | 43 | 93 | 42 | 87 | 203 | 173 |

1. Hall (1990)
2. Chu (1990)
3. McDonald et. al. (1993)
4. CRCNC (Costa Rica Caribbean North Coast)
5. Cartín (in prep.)
6. Quirós (in prep.)
7. Chaves et. at. (in prep.)

n. i: not information
S.D.: Standard Desviation
N: Size of the sample

TABLE 2

*Biometric measurements of leatherback sea turtle nesting on Gandoca beach, 1994*

| | |
|---|---|
| Average linear carapace length (D.S.=8.56) | 145.85 cm |
| Maximum linear carapace length | 186.0 cm |
| Minimum linear carapace length | 109.0 cm |
| Average linear carapace width D.S.=6.06) | 84.29 cm |
| Maximum linear carapace width | 107.0 cm |
| Minimum linear carapace width | 65.0 cm |
| Maximum curve carapace length | 205.0 cm |
| Minimum curve carapace length | 115.0 cm |
| Maximum curve carapace width | 129.0 cm |
| Minimum curve carapace width | 95.0 cm |

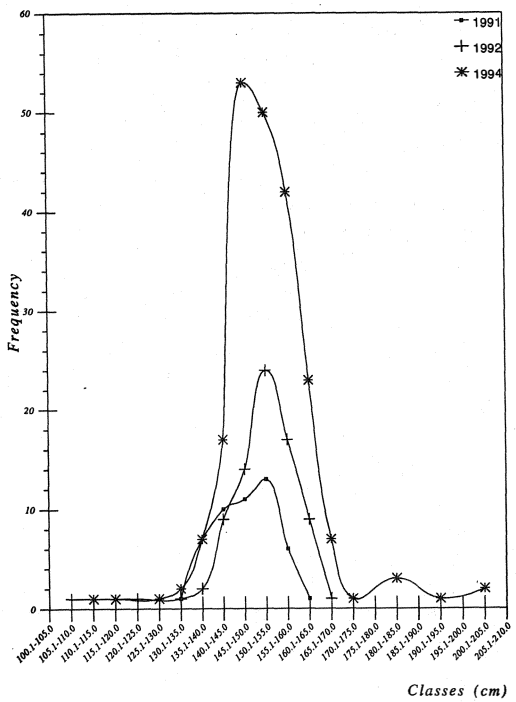


Fig. 6. Carapace curve length classes of the leatherback sea turtles on Gandoca beach to 1991, 1992 and 1994.

"yolked" eggs laid was 82.33 (Table 3). Cartín (in prep.) and Quirós (in prep.) reported means of 76 and 77 normal eggs/clutch respectively for leatherbacks at Gandoca for 1991 and 1992 respectively. 233 normal eggs selected at random from 30 nesters were measured. Mean diameter was 51.18 mm (S.D.: 3.2). Mean egg diameters at some other leatherback sea turtle rookeries range between 50 and 55 mm (Hirth & Ogren 1987 and Rueda *et al.* 1992).

TABLE 3

*General information about the hatchery and clutches on Gandoca beach*

| | |
|---|---|
| Clutches in the hatchery | 82 |
| Total normal eggs in the hatchery | 6 277 |
| Average N° normal eggs/clutch (S.D.=20.62) in the hatchery | 79.46 |
| Total yolkless eggs in the hatchery | 2 118 |
| Average N° eggs/clutch | 112 |
| Maximum clutch size | 158 |
| Minimum clutch size | 5 |
| Percent yolkless eggs | 31.03% |
| Mean yolkless eggs/nest (S.D.=15.02) | 29.81 |
| Maximum N° yolkless eggs | 76 |
| Minimum N° yolkless eggs | 5 |
| Average N° normal eggs/clutch | 82.33 |
| Total normal eggs removed from the beach | 12 807 |
| Total eggs removed (normal+yolkless) | 18 475 |
| Average normal egg diameter (N=233, S.D.= 3.2) | 51.188 mm |

Leatherbacks lay a number of smaller, yolkless eggs -"vanos"-along with normal size eggs. In a sample of 248 nests, the mean percent of yolkless eggs was 31.03% of the total clutch (Table 3). Cartín (in prep.) reported 33% yolkless eggs/clutch for Gandoca leatherbacks. In a sample of 20 clutches, the diameters of yolkless eggs ranged from 0.3-45 mm and the statistical mode was 28 mm. Rueda *et al.* (1992) reported a mean diameter of 29.17 mm for yolkless egg, from Urabá Gulf, Colombia. Most yolkless eggs are laid toward the end of oviposition. Possible adaptive values of yolkless eggs include; predator diversion, thermal buffering and to prevent sand from falling between the eggs thus allowing adequate space for gas exchange (Hall 1990).

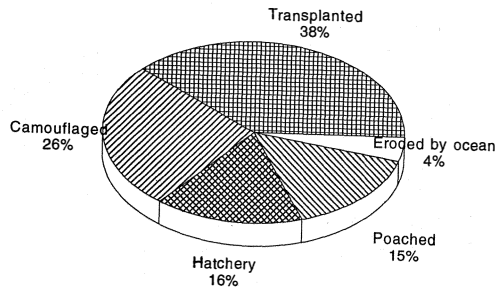


Fig. 7. Destination of leatherback sea turtles nests on Gandoca beach.

During our study, the most important impacts on the nests were; poachers, activity of domestic animals, and ocean erosion (Fig. 7). A program of relocation of eggs to a hatchery was adopted to offset these negative impacts.

Only clutches laid around the mouth of creeks, clutches laid in the intertidal zone and clutches confiscated from poachers were put in the hatchery. It is assumed that hatching rate for these eggs would otherwise be 0%. Eggs placed in the hatchery were carefully transplanted within one hour following oviposition. The eggs were counted and the yolkless ones placed on top of the normal eggs. A total 82 clutches, with 6277 normal eggs was placed in the hatchery. The average incubation period in the hatchery was 62.24 days (range: 56-68 days). Average hatching rate was 55.10% (S.D.: 25.04, range 15-96%). These results are similar to those reported in St. Croix (McDonald & Dutton 1993; Dutton & McDonald 1994). Unhatched eggs were opened and classifed as follows; no visible sign of an embryo (25.1 %); a pre-term embryo (4.0%); a full-term embryo (11.5%), or a dead hatchling (4.3%). Hatching success of relocated leatherback sea turtle eggs in Malaysian hatcheries has varied from 32 to 71.5% over a nineteen year period (Siow & Moll 1982, Mortimer 1990). Whitmore & Dutton (1985) recorded a 68.7 % hatch rate in relocated clutches of 50 eggs each in Suriname. Cartín (in prep.) and Quirós (in prep.) reported 42% and 15% hatching rates in a hatchery on Gandoca beach respectively and Alvarado & Figueroa (1989) reported a 69.9% hatch rate of leatherbacks in hatcheries in México.

TABLE 4

*Mean temperature (°C) from the hatchery*

| Month | Hour | Mean | Range | S.D. |
|---|---|---|---|---|
| | 6:00 am | 27.60 | 24-30 | 1.12 |
| March | 12:00 md | 28.60 | 26-34 | 1.18 |
| | 6:00 pm | 28.01 | 26-30 | 0.95 |
| | 6:00 am | 28.49 | 26-31 | 1.13 |
| April | 12:00 md | 29.03 | 26-32 | 1.03 |
| | 6:00 pm | 28.35 | 26-30 | 0.96 |
| | 6:00 am | 29.60 | 27-32 | 1.71 |
| May | 12:00 md | 29.71 | 27-30 | 0.92 |
| | 6:00 pm | 29.60 | 27-34 | 1.17 |
| | 6:00 am | 28.8 | 27-32 | 0.99 |
| June | 12:00 md | 29.4 | 27-32 | 1.01 |
| | 6:00 pm | 29.3 | 27-31 | 0.89 |
| | 6:00 am | 28.3 | 27-30 | 0.91 |
| July | 12:00 md | 28.9 | 27-30 | 1.00 |
| | 6:00 pm | 29.0 | 27-29 | 0.82 |

At Gandoca beach there are two periods of low temperature and high precipitation (February-March and May-July), which influence hatch rates and survival of hatchlings. Temperatures reported from the hatchery are presented in Table 4.

Natural nests were not studied but field patrols reported seeing the first hatchlings from camouflaged and relocated nests in the second week of May, the same period during which hatchlings began to emerge in the hatchery.

The mean straight carapace length of 573 hatchlings from the hatchery, measured and weighed within a few minutes after emergence, was 58.74 mm (S.D.: 3.074). The mean weight was 48.35 g (S.D.: 4.6803). Hirth & Ogren (1987) reported mean carapace lengths of hatchlings at some of the better known rookeries ranging from 55 to 63 mm and mean weights from 39 to 47 g.

Examination of nests from the hatchery revaled one albino hatchling and one case of twins; the latter phenomenon is well-known (Whitmore & Dutton 1985 and Eckert 1990).

REA analysis shows that nests have a high risk of loss within 100 m of the mouth of creeks. Other areas where natural hatching rates may be expected to be low are segments of the beach unusually susceptible to erosion (between markers 49-53 and 67-73) and segments near Gandoca Lagoon and Sixaola River which offer poachers easy access, with relatively low probability of detection.

Historically, poacher depredation began to be a serious impact with change in two not unrelated factors: a. the re-establishment of banana plantations in the Sixaola River valley and b. the gradual extension of Costa Rica's highway network.

Prior to these developments, Gandoca residents customarily harvested a few turtle eggs for domestic use, but as far as we can determine pressure on the population was at a sustainable level. The principal species exploited was the leatherback which is neither hunted for its shell nor esteemed for its meat. Worldwide reduction in its nesting population appears to be related to over harvesting of eggs.

In adition to erosion of the beach by the ocean and creeks, the beach at Gandoca has

been and continues to be affected by woody debris deposited by the littoral current, which hinders access to the berm and nest excavation by turtles. In recent years, the quantity of this material has increased greatly as a consequence of deforestation of watersheds by logging, but also as a consequence of the April, 1991 earthquake.

Predation by wild animals does not appear to be a major factor in Gandoca, but pigs occasionally prey on eggs and hatchlings, while horses and cows may kill hatchlings by compacting the sand. In addition poachers may train dogs to look for clutches.

Other anthropogenic factors which have been shown to stress leatherback sea turtle rookeries (Eckert *et al.* 1992) include;

* sand mining (occasionally practiced for the purpose of maintaining the highway to Gandoca).

* temporary drainage of small coastal swamps.

* artificial lights (in Gandoca, limited to bonfires on the beach).

* plastic products and pesticides (from banana farms, reaching the beach via rivers).

All of the above are regulated by the Wildlife Law (N°7317, 1992), the Gandoca/Manzanillo National Wildlife Refuge regulations and Gandoca/Manzanillo Sea Turtles Protection Decree (N°230069, 4/05/94). These stresses on leatherback sea turtles in Gandoca are very similar to those identified for rookeries in the West Indies (Eckert *et al.* 1992).

**Management recommendations:** 1. Regulate vehicular access to the area near the beach especially during Easter week; 2. Manage and protect principal nesting segments of the beach; 3. Develop educational materials and environmental education workshops for local people (in Gandoca and buffer zone communities); 4. Manage and protect all life stages of the leatherback sea turtle (eggs, hatchlings and females); 5. Carry out a socio-economic study of the local people to determine the feasibility of a leatherback sea turtle egg domestic use program. 6. Attenpt to develop alternative sources of income for poachers and local people (such as providing support services to the Earthwatch volunteer program).

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## RESUMEN

La tortuga baula fue estudiada en una importante playa de anidamiento al sureste de la costa Caribe de Costa Rica (82° 37' W; 09° 37' N). Un total de 530 nidos fueron registrados en playa Gandoca durante la temporada de anidamiento de 1994 (febrero a julio). El total de tortugas baulas marcadas fue de 160 individuos de los cuales cinco eran remigrantes de 1992 y otras 15 tortugas con marcas foráneas. 88 hembras fueron marcadas durante su primer anidamiento y no fueron vistas otra vez. Los datos demostrarón que el promedio de largo curvo del caparazón fue de 153.8 cm y promedio del ancho curvo del caparazón de 112.0 cm. Un total de 82 nidos con 6277 huevos normales fueron colocados en el vivero. El promedio del periodo de incubación en el vivero fue de 62.24 días (ámbito: 56-68 días). El promedio del ámbito de avivamiento fue 55.10% (D.E.: 25.04, ámbito 15-96%). La erosión del océano, la enorme cantidad de troncos y basura en la playa, así como, la actividad de los hueveros, representan los más cruciales problemas para los anidamientos de la baula en playa Gandoca.

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