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Leatherback Turtles (*Dermochelys coriacea*) on St. Croix, U.S. Virgin Islands: Fifteen Years of Conservation

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ABSTRACT. – **From 1981 to 1995, saturation tagging and consistent night patrols have yielded comprehensive information on every leatherback turtle (*Dermochelys coriacea*) nesting at Sandy Point National Wildlife Refuge, St. Croix, USVI. A total of 358 individual leatherbacks have been flipper-tagged, with 18 to 55 individual females per season. Annual remigration rates averaged 34.1%, and the most common remigration interval was two years. Turtles ranged in carapace length from 131.0 to 177.4 cm and in weight from 259 to 506 kg. The nesting period extends from 9 February to 11 August with each turtle laying an average of 5.26 nests per season with an internesting interval of 9.6 days. Clutch size averages 79.7 yolked eggs and 36.4 yolkless eggs. Incubation takes an average of 63.2 days with an *in situ* nest hatch success of 67.1% and a relocated nest hatch success of 60.4%. A few turtles encountered on Sandy Point were originally tagged on other beaches on St. Croix or on various beaches in Puerto Rico, including Culebra. Several turtles originally tagged on Sandy Point were later observed to nest at Vieques, Culebra, and Anguilla. One turtle stranded in New Jersey and another was caught in Mexico. Nearly half of the nests on Sandy Point were relocated to prevent loss due to predictable annual cycles of sand erosion and redeposition. Conservation efforts have reduced nest loss due to erosion to less than 5% and eliminated poaching of nests. We estimate that approximately 130,200 hatchlings emerged at Sandy Point from 1982 to 1995, possibly double the number that would have been produced without these efforts.**

KEY WORDS. – **Reptilia; Testudines; Dermochelyidae; *Dermochelys coriacea*; sea turtle; nesting biology; conservation; management; population; growth; St. Croix; U.S. Virgin Islands**

Leatherback turtles have probably been nesting on Sandy Point, St. Croix, USVI, for a very long time. This nesting population was first brought to the attention of biologists in the mid 1970s by Otto Tranberg, a USVI environmental enforcement officer. Tags were applied to six turtles in 1979.

In 1981 the USVI Division of Fish and Wildlife initiated a comprehensive study of the nesting biology of leatherbacks on Sandy Point, but the first season suffered from a shortage of personnel and this resulted in an incomplete data set for that year. Since 1982 the project has used Field Directors and Earthwatch (Watertown, MA) volunteers. Critical Habitat was established for the leatherbacks at Sandy Point in the water (National Marine Fisheries Service, 1979) and on the land (U.S. Fish and Wildlife Service, 1978). Sandy Point was acquired as a National Wildlife Refuge (NWR) in 1984 by the U.S. Fish and Wildlife Service.

The objectives of the Sandy Point leatherback project were to monitor the size and productivity of this population by documenting and tagging all nesting females. The main management objective was to maximize hatchling production by protecting nests from erosion, inundation, predation, and poaching. These objectives are still being addressed in this on-going project.

Sandy Point shares some of its leatherback turtles with other nesting beaches for this species in the northeast Caribbean. On St. Croix, a second nesting beach has had fewer than ten turtles annually since 1983 (T. Mizak, *pers. comm.*). On Culebra Island, approximately 90 km northwest of Sandy Point, 12 to 42 females have nested annually since 1984 (T. Tallevast, *pers. comm.*). Scattered nesting by leatherbacks occurs on other Virgin Islands and Puerto Rico beaches but not in numbers to justify regular monitoring. A decade of beach surveys in this Caribbean region has supported the conclusion that Sandy Point has the largest nesting population of leatherback turtles under US jurisdiction.

Numerous studies on the movements, biology, and physiology of leatherback turtles have been carried out on Sandy Point leatherbacks. Eckert and Eckert (1987, 1988) used growth rates of a tropical, pelagic epibiotic barnacle (*Conchoderma virgatum*) to determine the length of time that leatherback turtles had been in local waters before the first nesting of the season. That study suggested that turtles commence nesting within relatively

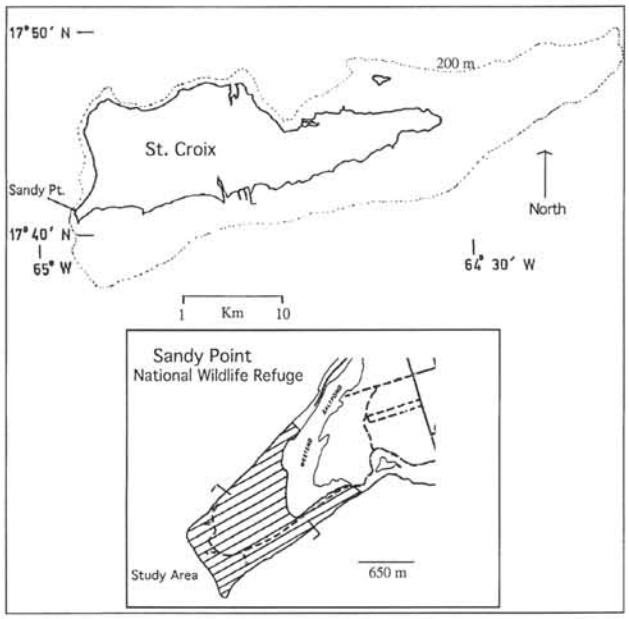

Figure 1. Location of the Sandy Point study area at St. Croix, U.S. Virgin Islands.

few days of arrival in tropical waters. In 1981 a tagged turtle stranded dead on a beach in New Jersey 85 days after last being seen at Sandy Point (Boulon et al., 1988). This provided the first indication that turtles migrate to north temperate waters from the Sandy Point nesting beach. Keinath and Musick (1993) studied internesting movements of a leatherback at Sandy Point with a satellite transmitter. Eckert et al. (1986, 1989) studied diving behavior in leatherbacks during internesting intervals. Time-depth recording units demonstrated that turtles dove to great depths (possibly greater than 1000 m) and remained submerged for up to 37 minutes (Eckert et al., 1986, 1989). Physiological studies at Sandy Point and necropsies done elsewhere have indicated that leatherbacks have relatively small lungs and depend instead on blood and tissue oxygen stores during deep dives (Lutcavage et al., 1990). Eckert (1990) studied monozygotic twinning in leatherbacks on Sandy Point and found ten turtles over four years that produced twins, two of which produced twins over consecutive breeding seasons. Twinning was not correlated with any selected reproductive parameters except greater numbers of yolked eggs in a clutch.

METHODS

The study area is a 3.0 km portion of the Sandy Point NWR (Fig. 1). This is a classic leatherback nesting beach, having a broad profile and nearby deep water access. To ensure encountering every turtle that nests on this beach, the area was patrolled hourly from 2000 to 0500 hrs every night from 1 April until 10 days after the last nest was laid. All nesting activities which did not result in oviposition were classified as "dry runs." All turtles that nested on Sandy Point were measured and tagged. During the course of the project turtles have been tagged on both front and rear flippers with a variety of tags. Monel tags (Hasco, size 19) were the most successful (McDonald and Dutton, 1994). Titanium (Stockbrands) and Inconel (#681) tags were subject to excessive biofouling and stress on the attachment point. Plastic tags (Riese size-2 "Flexible Jumbo", Dalton) had the lowest retention of any tags used (Eckert and Eckert, unpublished data). Beginning in 1992, each turtle was also tagged with a PIT (Passive Integrated Transponder) tag made by AVID. The tiny, glass-encased microchip was injected into the shoulder muscle and read with a portable AVID scanner (Dutton and McDonald, 1994). Photographs of most individual turtles' "pink spot" were taken since 1986. These were used to identify indi-

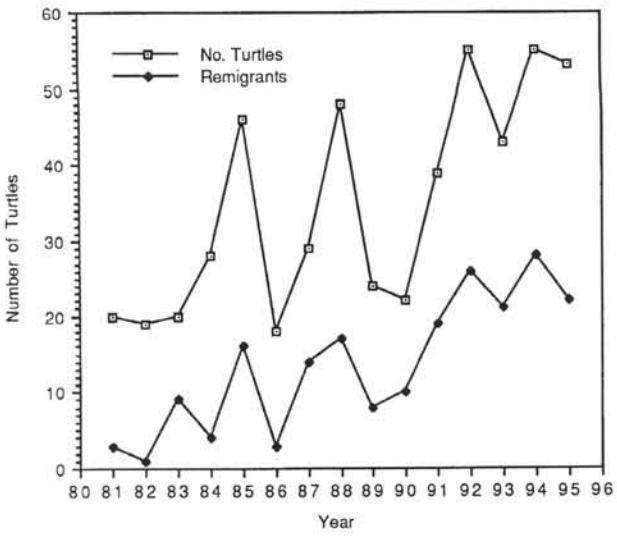

Figure 2. Annual number of leatherback turtles and remigrants, Sandy Point, St. Croix, from 1981 to 1995. Numbers of remigrants are based on flipper tags.

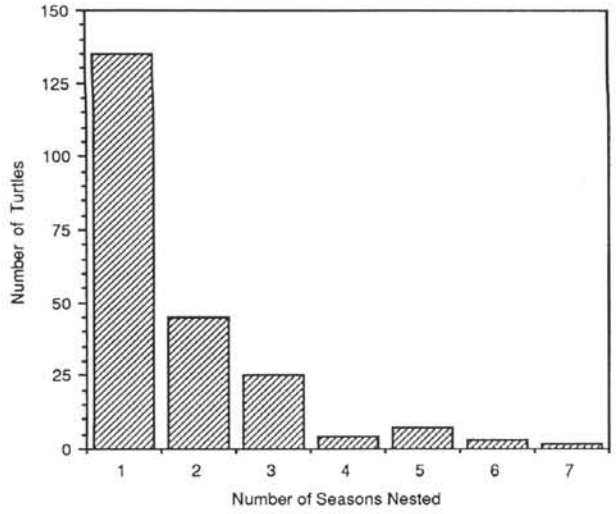

Figure 3. Frequency distribution of number of seasons nested by individual leatherback turtles at Sandy Point, St. Croix, from 1979 to 1993. Turtles tagged in 1994 and 1995 are not included as they may still be in their internesting interval.

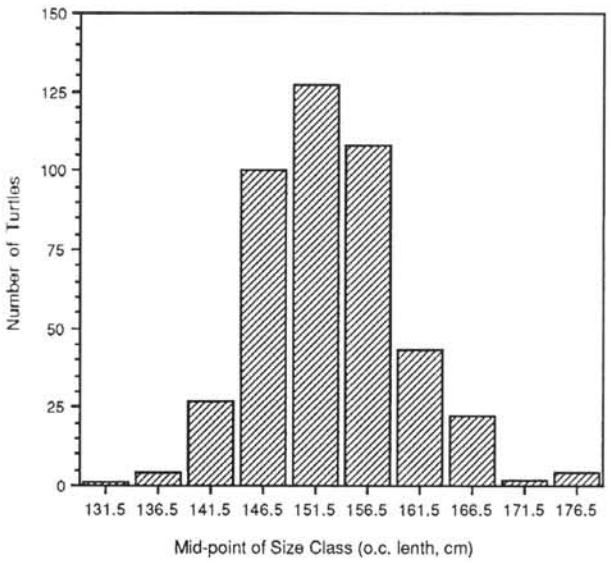

Figure 4. Size class distribution of leatherback turtles nesting at Sandy Point, St. Croix, from 1982 to 1994.

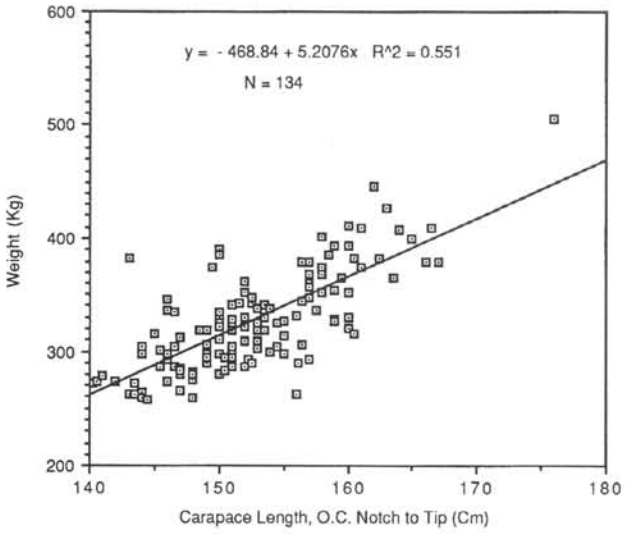

Figure 5. Length vs. weight analysis of leatherback turtles nesting at Sandy Point, St. Croix, from 1985 to 1990.

viduals that lost all flipper tags (McDonald et al., 1996; McDonald and Dutton, in press; McDonald and Dutton, 1996).

All nest locations were recorded using numbered stakes placed every 20 m along the beach. Triangulation from the nearest two stakes provided location to within 10 cm and enabled each nest to be monitored. Predictable annual cycles of sand erosion and redeposition is the most serious natural threat to nests on this beach. To obviate this threat, all nests laid in known erosion-prone areas on the beach were relocated to stable parts of the beach immediately after laying. Nest dimensions were duplicated and relocated sites were similar to original nests. Relocation was generally accomplished within one hour of oviposition. Nests were excavated within several days after emergence to calculate hatch and emergence success.

Data from this project are presented from 1982 to 1995. Remigration rates and number of seasons nested were calculated using all turtles tagged from 1981 to 1993, as those tagged in 1994 and 1995 may still be in their internesting interval.

RESULTS

From 1979 to 1995, 358 individual leatherback turtles were flipper-tagged on Sandy Point. Since 1981, when consistent beach patrols began, between 18 and 55 turtles have nested each year (Fig. 2). Based on flipper tag returns, annual remigration rates averaged 34.1% from 1982 to 1995. Correcting for tag loss brings the remigration rate up to 46.8% (see discussion below). Remigration intervals have most commonly been two years (61.4%), followed by three-year (30.3%), four-year (6.9%), five-year (0.7%), and one-year (0.7%) intervals.

Based on flipper tag returns, only 41.6% of Sandy Point leatherbacks were observed in more than one season, with 23.8% observed nesting in two seasons, 10.8% in three, 1.7% in four, 3.0% in five, 1.3% in six, and 0.9% in seven (Fig. 3) (see discussion below). One of the two seven-season nesters was turtle G603, originally tagged in 1979 and observed nesting again in 1981, 1983, 1985, 1987, 1990, and 1992 (Boulon, 1994). The other seven season nester was turtle AAG304, first tagged in 1981, that returned every two years up to 1993.

During the course of this project a number of inter-beach and inter-island movements and nesting activities were documented within seasons. With the start of the Manchenil Beach (St. Croix) project in 1983 and the Culebra Island project in 1984, the documentation of these inter-beach nesting movements became possible.

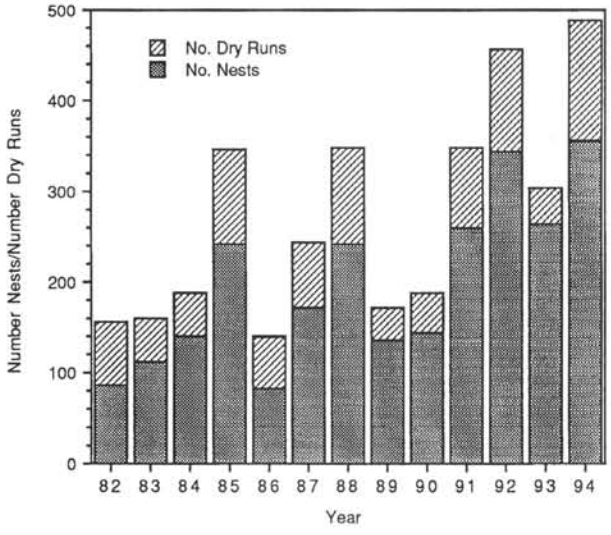

Figure 6. Number of nests and dry runs at Sandy Point, St. Croix, from 1982 to 1994.

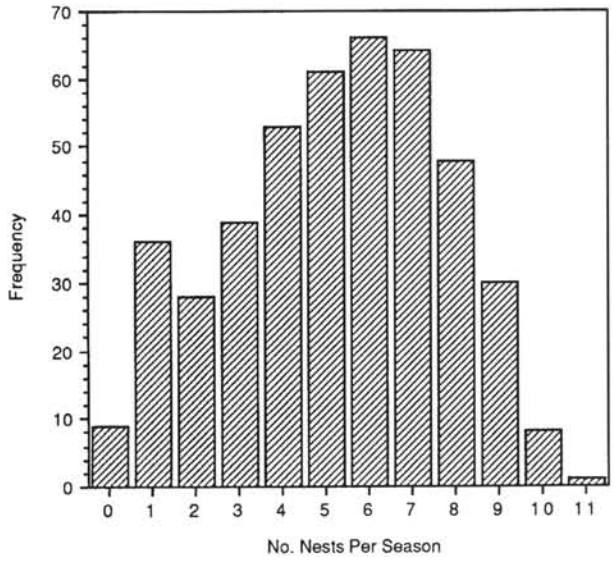

Figure 7. Frequency distribution of number of nests laid per season by individual turtles at Sandy Point, St. Croix, from 1982 to 1994. This figure includes nine non-nesting turtles that were observed on the beach.

Since 1984, six turtles have nested on both Sandy Point and Culebra, two have nested on both Sandy Point and Puerto Rico beaches, and eleven have nested on both Sandy Point and Manchenil Beach. All are believed to have nested at least once on the beach where originally tagged during the season in which the inter-beach movements occurred, although difficulties in obtaining information from original tag sources have made it hard to be certain. In 1989 a leatherback turtle fitted with a satellite transmitter was documented to nest three times on Sandy Point, once on Vieques Island, and finally four times on Culebra during that season (Keinath and Musick, 1993). In 1988, another turtle nested eight times on Sandy Point and then on Anguilla (S. Monsanto, *pers. comm.*). One of 20 turtles tagged in 1981 was found stranded in Atlantic City, New Jersey, 85 days after her last nest on Sandy Point (Boulon et al., 1988). Death was presumably caused by blockage of the ileocecal valve by a clay-like fecolith (R. Schoelkopf, *pers. comm.*). In 1988, a turtle that had nested two years previously on Sandy Point was caught by a shark fisherman in the Triangle Cays, Campeche, Mexico (F.S. Celada, *pers. comm.*).

Turtles nesting on Sandy Point have ranged in carapace length from 131.0 to 177.4 cm (over the curve, notch to tip) with the greatest number in the 149 to 154 cm size class (Fig. 4). Weights (n = 134) were obtained from 1985 to 1990 from 102 different turtles and ranged from 259 to 506 kg. Length vs. weight shows a positive regression of $y = 5.2076x - 468.84$ with $r^2 = 0.551$ (Fig. 5).

Nesting activity ranged from an early season nest on 9 February to a last nest on 11 August. Peak nesting period occurred in mid- to late May. From 1982 to 1994, 71.6% of all nesting activities resulted in egg deposition (range = 54.7% to 87.0% per annum, SE = 8.80) (Fig. 6). Turtles laid a mean of 5.26 nests per season (range = 3.90 to 6.03 per annum, SE = 0.73) with a maximum of 11 nests laid for a single turtle in one season (Fig. 7). This may be an underestimate of annual nesting since females may have also nested unobserved on other beaches or earlier in the season. The mean observed internesting interval was 9.6 days (range = 9.4 to 9.8 per annum, SE = 0.15).

Mean total clutch size was 116.1 eggs (range = 112.7 to 119.3 per annum, SE = 2.11) with a mean of 79.7 yolked eggs (range = 72.9 to 85.9 per annum, SE = 3.99) and a mean of 36.4 yolkless eggs (range = 31.2 to 41.6 per annum, SE = 3.17). Incubation periods ranged from 57 to 76 days with a mean of 63.2 days (SE = 1.34). The longer incubation periods occurred early in the season when sand temperatures were cooler. From 1981 to 1995, nests laid per season ranged from 82 to 355 with a total of 2905 nests observed (Fig. 6).

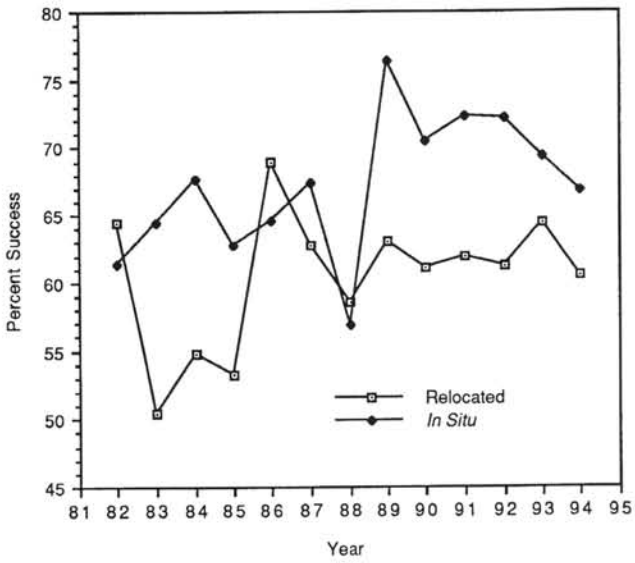

Figure 8. Hatch success of relocated nests vs. *in situ* nests of leatherback turtles at Sandy Point, St. Croix, from 1982 to 1994.

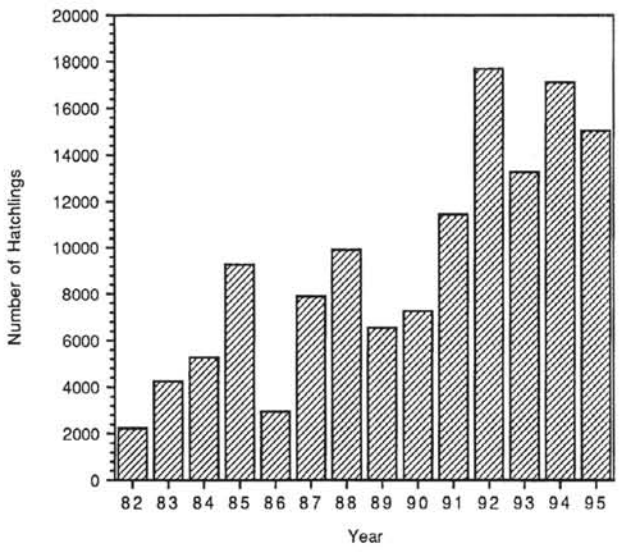

Figure 9. Number of leatherback hatchlings emerged each year at Sandy Point, St. Croix, from 1982 to 1995.

Table 1. Annual loss of leatherback nests due to beach erosion and poaching at Sandy Point, St. Croix, from 1981 to 1994.

Year	Total Nests	Nests Lost to Erosion		Nests Lost to Poaching	
		n	%	*n*	%
1981	119	48	40.3	13	10.9
1982	86	26	30.2	0	0.0
1983	113	9	7.9	2	1.8
1984	141	7	4.9	1	0.7
1985	242	17	7.0	3	1.2
1986	82	8	9.8	0	0.0
1987	171	6	3.5	0	0.0
1988	242	4	1.7	0	0.0
1989	137	4	2.9	0	0.0
1990	143	1	0.7	0	0.0
1991	260	13	5.0	0	0.0
1992	345	21	6.1	0	0.0
1993	264	6	2.3	0	0.0
1994	355	12	3.4	0	0.0

Beginning in 1982, many nests laid on Sandy Point were relocated to prevent loss to erosion, with 46.4% relocated to date. Hatch success rates (number hatched shells/number yolked eggs laid) for relocated vs. *in situ* nests varied considerably (Fig. 8). In two of the years, hatch success for relocated nests was higher than *in situ* nests, in nine years the reverse was true, and in one year there was no significant difference (Fig. 8). Overall, *in situ* nest hatch success was higher with a mean of 67.1% (range = 56.9 to 76.4 per annum) than for relocated nests at 60.4% (range = 50.5 to 69.0 per annum). Using average clutch sizes and average emergence success (hatch success minus dead hatchlings) for each year, we estimate that approximately 130,200 hatchlings emerged at Sandy Point from 1982 to 1995 (Fig. 9).

Before 1982, when nest relocation began, we estimate that up to 60% of nests laid on this beach annually were lost to erosion. Relocation efforts have reduced this loss to between 0.7% and 9.8% annually (Table 1). Some loss has still occurred during tropical storms or when early season nests (February–March) were not observed at the time of laying. Likewise, prior to 1981, poaching of nests was reported to approach 100% annually (O. Tranberg, *pers. comm.*). Our nightly presence on the beach throughout the nesting season has reduced that amount to between 0.0% and 1.8% per year with no known poaching since 1986 (Table 1).

Since its beginning, the educational value of this project has increased remarkably. In St. Croix, both locals and visitors to the island have demonstrated an increased awareness and desire to learn about sea turtles in general and leatherbacks in particular. As more people have become exposed to leatherbacks, proprietary interest has increased the protection afforded this population. Since 1981, over 6000 people have visited this project with an annual maximum of 750 in 1992 (Fig. 10). In recent years the visitor focus has been on school and other youth groups.

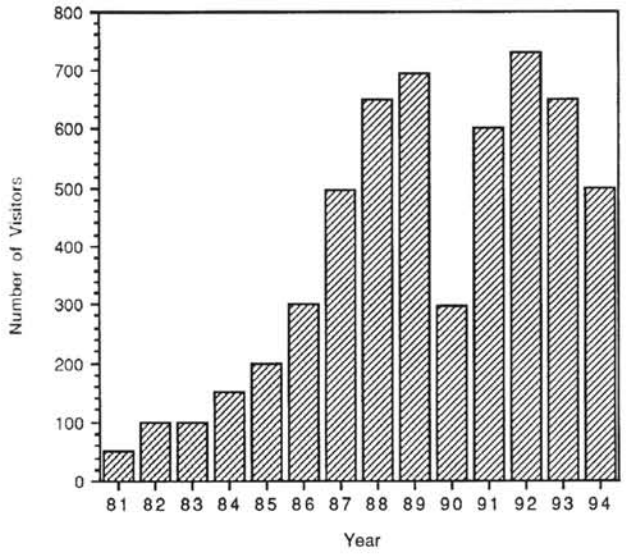

Figure 10. Number of visitors to the Sandy Point leatherback project from 1 April to 31 August, 1981 to 1994.

DISCUSSION

The Sandy Point population of leatherback turtles is the largest known nesting population of leatherbacks under US jurisdiction. Given the movements between this and other nearby aggregations, the Sandy Point aggregation may represent part of a larger population with subgroups having stronger fidelity to particular beaches.

Although 358 turtles have been tagged over the course of this project, it has become evident that many of these turtles were actually remigrants that had lost all their flipper tags since the last time they were seen, and were incorrectly identified as new turtles (McDonald and Dutton, in press). In a separate study, McDonald and Dutton (1996) have obtained a revised estimate of 293 separate turtles based on data from photoidentification and PIT tagging through 1995. Consequently, the flipper tag return data reported here (35.1%) underestimates remigration, which averages 46.8% after correction for misidentified remigrants based on photoidentification (see McDonald and Dutton, 1996). Further, the number of turtles seen in more than one season is actually higher than reported here. The numbers presented here represent typical data from most nesting beach studies worldwide, that is, uncorrected for tag loss. The use of unique physical characteristics ("pink spot") and internal "permanent" tags (PIT) is enabling researchers to develop more accurate estimates of actual numbers of turtles nesting at a particular location.

Although the leatherback has become a symbol of the conservation effort on St. Croix, in the absence of all-night patrols, poaching of nests would most likely occur again. Green and hawksbill turtle eggs and adults are frequently taken on Sandy Point after seasonal all-night patrols for leatherbacks have ended, and eggs of all three species are taken on other beaches around St. Croix.

Prior to 1981, human take and beach erosion most likely resulted in minimal hatchling production (O. Tranberg, *pers. comm.*). This may be reflected by the relatively small size of the nesting population in the early years of the project. We believe that continued relocation of nests on Sandy Point is essential for the long term recovery of this population of leatherbacks. Despite the slightly lower hatch rates in relocated nests, this action has resulted in the total production of approximately 53,400 hatchlings from clutches that would otherwise have been lost due to beach erosion. Lower hatch rates in relocated nests may be due to a greater number of pipped, dead hatchlings in these nests as compared to *in situ* nests (Eckert and Eckert, 1990). On Sandy Point, the greatest amount of developmental mortality occurs at this stage. Various attempts to reduce this stage mortality using different nest configurations and introducing oxygen at hatching have met with little success. Recent experiments relocating nests to styrofoam boxes just prior to hatching has shown positive results (Dutton and McDonald, unpublished data).

The Sandy Point beach can be described as a typical leatherback nesting beach (Pritchard, 1971). High energy beaches with no offshore submarine structures tend to be very dynamic. This results in sometimes extreme erosion/deposition cycles. Leatherbacks on Sandy Point appear to have adapted to this regimen by laying a large number of smaller nests, dispersed along the width and length of the beach (Eckert, 1987). This has enabled this species to reduce the chances that a high amount of reproductive output will be lost in any one area on the beach.

While the pivotal temperature for sex determination of leatherbacks has not been established for Sandy Point, Basford and Brandner (1989) studied the daily and seasonal temperature regime. Using the pivotal temperature from Suriname (Mrosovsky et al., 1984) they predict that Sandy Point may have produced more females than males during the course of their study. They further determined that relocation of nests on Sandy Point had no effect on the natural sex ratio of the hatchlings.

It has been generally accepted, but never proven, that female sea turtles return to their natal beaches to nest (Carr, 1967; Meylan et al., 1990). This theory has recently been supported through genetic work on Sandy Point and other Caribbean leatherback nesting beaches which indicates that the Sandy Point population is relatively distinct from other populations (Dutton, 1995). It therefore seems possible that the nesting population will gradually increase as a result of the increase in numbers of hatchlings produced following management initiated in 1982. Such an increase in the numbers of nesting females may have begun in 1991, nine years later, and if these are indeed turtles that originated on Sandy Point, this would support the theory that leatherbacks grow and mature faster than other species of sea turtles (Rhodin, 1985; Zug and Parham, 1996). However, this conclusion may be premature given the annual variation in nesting numbers common in sea turtles. This population will need to be monitored for several more years before a trend can confidently be established.

Acknowledgments

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