Tagging and Nesting Research on Leatherback Sea Turtles (*Dermochelys coriacea*) on Sandy Point, St. Croix, U.S. Virgin Islands, 2003

Annual Report to Fish and Wildlife Service

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ABSTRACT

The Sandy Point National Wildlife Refuge in St. Croix, U.S. Virgin Islands supports the largest continuously studied population of nesting leatherback sea turtles in the world. Flipper tagging began in 1977, and since 1981 saturation tagging and consistent night patrols during the nesting season have yielded a comprehensive database of information on each female nesting at Sandy Point. The 2003 nesting season began with a nest discovered during U.S. Fish and Wildlife surveys on February 21st, and ended with a final potential nest on August 11th. Activity was highest during the weeks of May 6th and May 27th. One hundred seventy-two turtles laid a total of 974 nests with an average of 79.9 ± 19.8 yolked eggs per clutch. Of nests laid in 2003, 330 (34%) were relocated to protect them from inundation or erosion. The number of documented nests per female ranged from 0 - 10 with an average of 5.4. One hundred fourteen of the turtles were remigrants, with remigration intervals of 2 - 7 years. Of the 440 nests analyzed, mean overall hatch success was 59.6 ± 23.38%. Like most previous years, emergence success of *in situ* nests was significantly higher than that of relocated nests ($p<0.01$). We estimate that 4% of the nests were lost to erosion. With the addition of 58 untagged turtles in 2003, a total of 691 leatherbacks have been tagged since 1977. Nightly patrols and a concerted relocation effort have reduced the major historical threats of poaching and erosion, although there is still poaching of both eggs and adults of green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles after nightly patrols cease.

INTRODUCTION

For the twenty third consecutive season research has continued on the nesting ecology and population biology of the endangered leatherback turtle (*Dermochelys coriacea*) at the Sandy Point National Wildlife Refuge (SPNWR), St. Croix, U.S. Virgin Islands. The objectives of the project are to assess the size, productivity, and management priorities of this population (by documenting and tagging all nesting females), to protect adults, nests and hatchlings from predators and poachers, and to protect nests from erosion and inundation. The leatherback is the largest and most morphologically divergent species of sea turtle. The biology of this little-known reptile is reviewed in Marquez (1990). Pelagic in nature, it is rarely encountered except on the nesting beaches, where virtually all of the information on this species has been collected. The SPNWR supports the largest and best-studied nesting population of endangered leatherback turtles in the United States and northern Caribbean. As recently as a decade ago, there were only 13 significant nesting sites worldwide (Sternberg 1981), including six in the western Atlantic (Carr *et al*. 1982). However, leatherbacks have been virtually eliminated from some of these nesting sites, and have declined on almost all beaches where they are known to nest (Betz and Welch 1992, Chan and Liew 1996, Sarti et al. 1996, Spotila et al. 1996). In contrast, numbers are increasing on Sandy Point and on Culebra, Puerto Rico, where a similar project has been ongoing since 1984 (McDonald Dutton and Soler 1997). This could be due to intensive long-term conservation efforts on these beaches. This project provides a unique opportunity to study recruitment into a population that appears to be recovering from previously declining numbers. The Sandy Point beach and surrounding waters have been designated as critical habitat by the National Marine Fisheries Service, and in 1984 became part of the U.S. Fish and Wildlife Service's Caribbean Islands National Wildlife Refuge System. This study began in 1981 under the auspices of the U.S. Virgin Islands Department of Planning and Natural Resources, Division of Fish and Wildlife. Funding is provided through Section 6 Endangered Species grants of the U.S. Endangered Species Act and, since 1982, by Earthwatch and the Center for Field Research, Watertown, Massachusetts. Further information on the history of Sandy Point and the development of the present study can be found in Eckert and Eckert (1985).

The following is a summary of the results of the 2003 data, including comparisons with previous years. Detailed information from those years can be found in Eckert *et al*. (1982, 1984), Eckert and Eckert (1983, 1985), Basford *et al*. (1986, 1988, 1990), Brandner *et al*. (1987, 1989), Boulon (1992), McDonald *et al*. (1991, 1993, 1995, 1996, 1997, 1998, 1999, 2000, 2001), Dutton *et al*. (1992, 1994), and Alexander *et al.* (2002).

Study Area

The study area at Sandy Point national Wildlife Refuge (Figure 1) is 3.0 km long, with numbered stakes marking the entire length of the study area. Stakes placed along the vegetation line at 20M intervals enable us to obtain exact measurements on nest locations within the Refuge. The beach is divided up into 2 sections, including the

Sandy Point National Wildlife Refuge, St. Croix

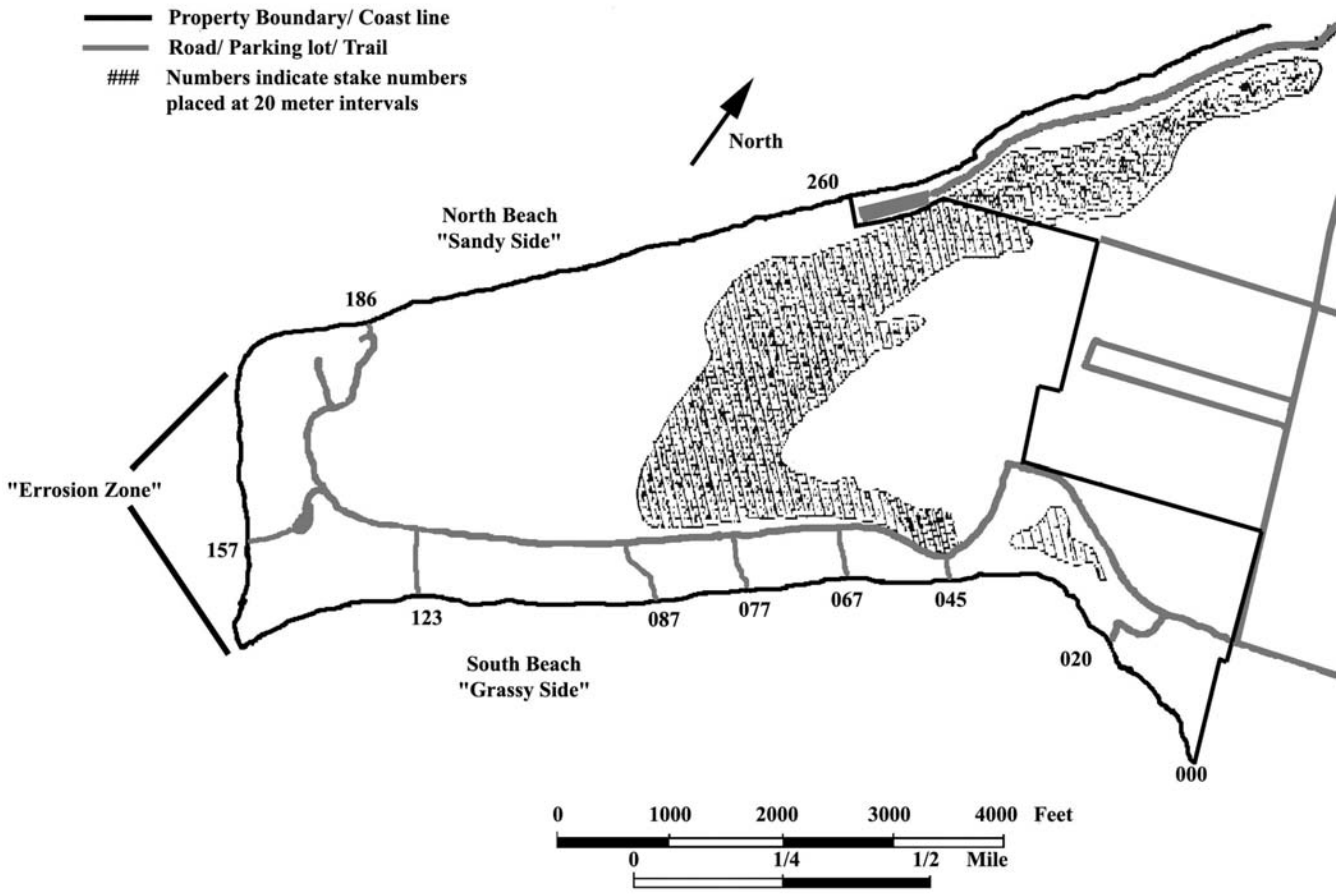

Figure 1. Schematic of Sandy Point National Wildlife Refuge. The drawing shows boundaries, coastline, roads, trails and stake numbers. The stippled areas represent salt ponds, which may be seasonally filled with water.

"grassy" side and the "sandy" side. The sandy side covers stakes 210 to 140 (the point). This half of the beach faces North and West, on the leeward side of St. Croix. It is relatively wide and contains very little vegetation extending out onto the sand, thus the label "sandy" side. The Western portion of the beach on this side erodes away during the nesting season from approximately stake 140 to stake 169. Erosion patterns result in extensive loss of beach so that at times, less than 2 meters of beach remain. This area of sandy side beach is thus referred to as the "erosion zone". The sand which erodes away from this area re-deposits itself in the area from 170 to 186 on the North side of the beach during the nesting season. This area is called the accretion zone. The process reverses itself during the winter months when the erosion zone refills with sand. This is an annual occurrence which is an indication of the dynamic forces driving the sand transport on Sandy point.

The grassy side of the beach faces south and is located on the windward side of the island. As a result, the beach is covered with windblown seaweed and debris. Additionally, the beach is covered with an overgrowth of vegetation (grass and sea grape), which occurs naturally on this side of the beach. Due to the extensive ground cover, therefore, this side is referred to as the "grassy" side. The stakes patrolled on the grassy side are numbered 45 to 139. Stakes 0 to 45 have little or no sand available for suitable leatherback nesting habitat.

In 2001, sand accretion occurred north of stake #195, covering rocks and providing an additional area for leatherbacks to emerge and Nest north of the traditional study area. There was no accretion in 2002, therefore, the study area only extended to stake #198. The area further north into the 200's was exposed rock and coral in 2002 preventing nesting activity. Occasionally, the area was patrolled further north into the 220's. The grassy side was patrolled regularly to stake 66, and occasionally to stake 45.

METHODS

Study Area Coverage

Nightly beach patrols on Sandy Point began starting April 1st 2003. The beach was patrolled nightly on foot, starting at 2000 hours and continuing until either 0500 hours, or until the last female finished nesting. Starting on April 6th the researchers were assisted by 9 teams of up to 10 Earthwatch volunteers per team, each participating for a period of 10 days, until the teams ended July 14th. The teams of volunteers were divided into 3 groups, each organized and led on patrols of the beach sections by a qualified Field Leader. Each group walked their respective study area at 45 minute intervals. As previously determined, leatherbacks require at least 1 and 3/4 hours to complete the nesting process, therefore, patrolling the beach at these intervals ensured that all nesting turtles were observed, tagged, and recorded.

Data Collection

Every time a turtle was encountered on the beach a separate nesting data sheet was completed (Appendix I). All data regarding nesting, identification, morphology, nest parameters, and behavior were recorded. Time and date of every encounter was also recorded. Nests were excavated once hatchlings emerged. Date of emergence and excavation were recorded. Upon excavation, all nest contents were categorized to determine nest success, and all un-hatched eggs were opened to determine stage of development. This information was recorded on a hatchling data sheet. Basic data collection remained the same as previous years. Green and hawksbill activities were also documented during the period of leatherback research.

Methods used to collect data were as follows:

A. Morphology

Over the Carapace (o.c.) length and width were recorded once a turtle successfully nested. Carapace length was recorded in centimeters using a standard metal measuring tape. The carapace was measured from the nuchal notch, alongside the vertebral ridge, to the posterior tip of the peduncle at the longest point. Width was measured from each side ridge, across the widest point of the carapace, just posterior to the front flippers. Individuals were measured every time they were encountered, and the measurements averaged at the end of the season.

B. Nesting

Whenever possible nesting behavior and technique were observed and any anomalies recorded. Abnormalities in digging, condition of rear flippers, nest cavity structure, and condition of sand in the nest were noted.

C. Relocated Nests

Any nests that appeared to be in imminent danger of erosion or inundation were relocated. All nests in the area previously designated as the erosion zone, in addition to those with standing water in the nest cavity were also relocated. Eggs from “doomed” nests were collected upon deposition, before they contacted the sand in the nest cavity, and placed in a traditional plastic hefty cinch sac bag. The eggs were then transported to a safer, stable area of the beach, where they were relocated in nests constructed by the field leaders or Fish and Wildlife Refuge staff. Nests were constructed (generally in the accretion zone) to specified shape and dimensions (Dutton *et al*. 1992), similar to natural nests. The locations of all relocated nests were recorded, along with the number of yolked and yolkless eggs deposited. Average depth, width and overburden (depth of sand over the eggs,

measured from the top of the egg mass to the sand surface) were also documented for each nest.

D. Marginal Nests

Nests that were deemed to have a reasonable chance of survival, in spite of their location relatively close to the high water mark, or inside the erosion zone, were left *in situ* and recorded as "marginal". Nests were left *in situ* in order to minimize the potential of skewing the hatchling sex ratios. Moving nests, such as marginal nests which likely incubate at cooler temperatures due to wave washover, would inhibit the production of male hatchlings.

E. Nest Location

The location of each nest was determined by measuring the distance from the center of the nest cavity to each of the two nearest marker stakes. A standard metric 50m tape was utilized and the distance recorded in meters. The distance of each nest to the vegetation line and high water mark was also recorded. The 50m tape was placed in a straight line between the nest cavity and the stake line, in addition to the nest cavity and the high tide mark, and the distances recorded.

F. Tagging

Inconel tags were attached to the inguinal skin flap between the rear flipper and the tail of every untagged turtle. In previous seasons Monel tags were applied, however, Monel tags are no longer produced and therefore the smaller Inconel tags were utilized. Traditional tagging pliers were used to attach the flipper tags. No tags were applied to the front flippers of leatherbacks due to decreased retention rates. Flipper tags were applied to both front and rear flippers of hawksbill and green turtles.

Turtles were also tagged with a small (14 mm long x 2 mm diam.) glass-encased electromagnetically encoded microchip, or Passive Integrated Transponder (PIT) tag (AVID, Inc., Norco, CA). The tags were injected using a plastic applicator gun, directly into the left or right shoulder muscle of each turtle as described in McDonald and Dutton (1996). The tags were detected using hand held scanners (AVID Power Tracker II and IV) which when passed over the shoulder area, displayed the I.D. number on a digital scanner screen. The numbers of all applied and detected PIT tags were recorded on the nesting data sheets. All tagging procedures were designed to cause minimal disturbance to the turtles. No PIT tags were applied unless the turtle commenced laying eggs (for approximately 5 minutes), was motionless, and had entered the nesting trance.

No PIT tags were applied if the turtle had finished laying or started the disguising phase.

G. Emergence and Excavation

Nests were monitored nightly, three days before the expected emergence date. After emergence, the location, date, time and number of hatchlings seen were recorded. A wooden stick, with a piece of tape denoting the location and identification number of the nest, was placed behind the emergence area to mark the spot for future excavation. Live hatchlings were guarded from potential predators until they successfully entered the water. Disoriented hatchlings, those wandering the beach, going away from or parallel to the water, or hatchlings trapped in vegetation, were assisted to the waters edge. If a nest did not emerge within the expected time frame it was excavated to ensure that no hatchlings were trapped inside, and to reduce the high full-term pipped mortality often seen in relocated nests.

After emergence, the nests were excavated and the nest contents categorized to determine hatching success. All un-hatched eggs were opened to determine stage of development, using criteria described by Whitmore and Dutton (1985) (Appendix II). Additional sub-categories of development were added for the 2002 nesting season. All abnormalities were described. The condition of the nest cavity was noted to help determine possible causes for poor hatch success. This included extremely wet or dry sand, as well as the presence of mold, roots, and other vegetation. Live hatchlings found within the nest cavity were counted and released. Hatchlings were dispersed along the beach where they emerged, as well as on grassy side. Any eggs or live hatchlings that were not ready for release were brought back to Cottages by the Sea and incubated in Styrofoam coolers until they were ready to be re-released at Sandy point.

H. Blood and Tissue Samples

Blood or tissue samples were taken from adult turtles for genetic analysis. Blood samples were taken from veins in the rear flip using a 21 gauge needle following methods described in Dutton (1996), without disturbing or harming the turtles.

Alternatively, small skin samples (6mm diameter) were taken using a sterile biopsy tool (Dutton and Balazs 1995) or a razor blade. All sampling was carried out during or shortly after the turtle laid her eggs, to ensure the least disturbance to the nesting process.

Skin samples were placed in a salt DMSO solution, labeled and frozen. Blood samples were refrigerated for 1 day. Once the blood separated out it was spun down using a centrifuge, placed in a labeled vial containing anti-lysis solution, and frozen.

Trample Zone

In addition to the traditional research, an additional experiment known as the trample zone experiment, was continued during the 2003 nesting season. The purpose of this experiment was to determine the effect, if any, of heavy foot traffic on nest success. In order to conduct this experiment a section of beach was set aside where no foot traffic was allowed. This area of beach was called the "no trample zone". The no trample area extended 40m long from stake 177 to stake 179 on the sandy side of the beach. It started approximately 1m from the vegetation line (this 1m zone along the vegetation provided a foot path for researchers and volunteers to walk) and extended to the water line. The entire area was staked, posted, and roped off to prevent entry by all personnel. The signs were erected to inform any visitors to the beach that the area was off limits for recreational use. The only time entry was allowed in the no trample zone was if a turtle was present in the area, or if nests were being relocated to the area. An adjacent 40m length of beach, from stake 179 to 181 was denoted the trample zone. The trample zone extended from the vegetation line to the water line. This area of beach was patrolled hourly as normal, in addition to the normal presence of personnel going to and from the water, attending to turtles, and relocating nests. This area of the beach also remained available for recreational use.
All adult and hatchling data was collected as normal in both sections of the beach, and hatch success was compared among the two sections.

Dataloggers

Electronic dataloggers recording temperature at 15 minute intervals were placed in 9 *in situ* and 9 relocated nests. The dataloggers were placed in the middle of the nest after approximately half the eggs were already in the chamber. Nest locations were recorded and the dataloggers removed upon excavation, once the nest had fully emerged. The purpose of this preliminary study was to determine if there is a lethal temperature associated with relocated nests that does not occur in *in situ* nests. If a significant difference in temperature is found prior to, or slightly after hatching, this may help explain the high mortality of relocated versus *in situ* nests.

RESULTS

Adults

During the 2003 nesting season 172 adult leatherback sea turtles were observed at Sandy Point (Figure 2). This included 58 previously untagged turtles and 114 remigrants. Of the 114 remigrants, 4 turtles were originally tagged in Culebra, an island off the coast of Puerto Rico, and 2 turtles were unidentifiable (although presumably tagged at Sandy Point). The remigration interval for all turtles ranged from 1 to 7 years with an average remigration interval of 2.43 years (Table 1). Information has not been obtained on the remigration intervals of the 4 Culebran turtles. Remigration intervals were similar to previous years. The carapace lengths of the recorded turtles ranged from 134.5 to 170.5 cm with an average of 153.2 cm ± 6.4 cm. The carapace widths of the recorded turtles

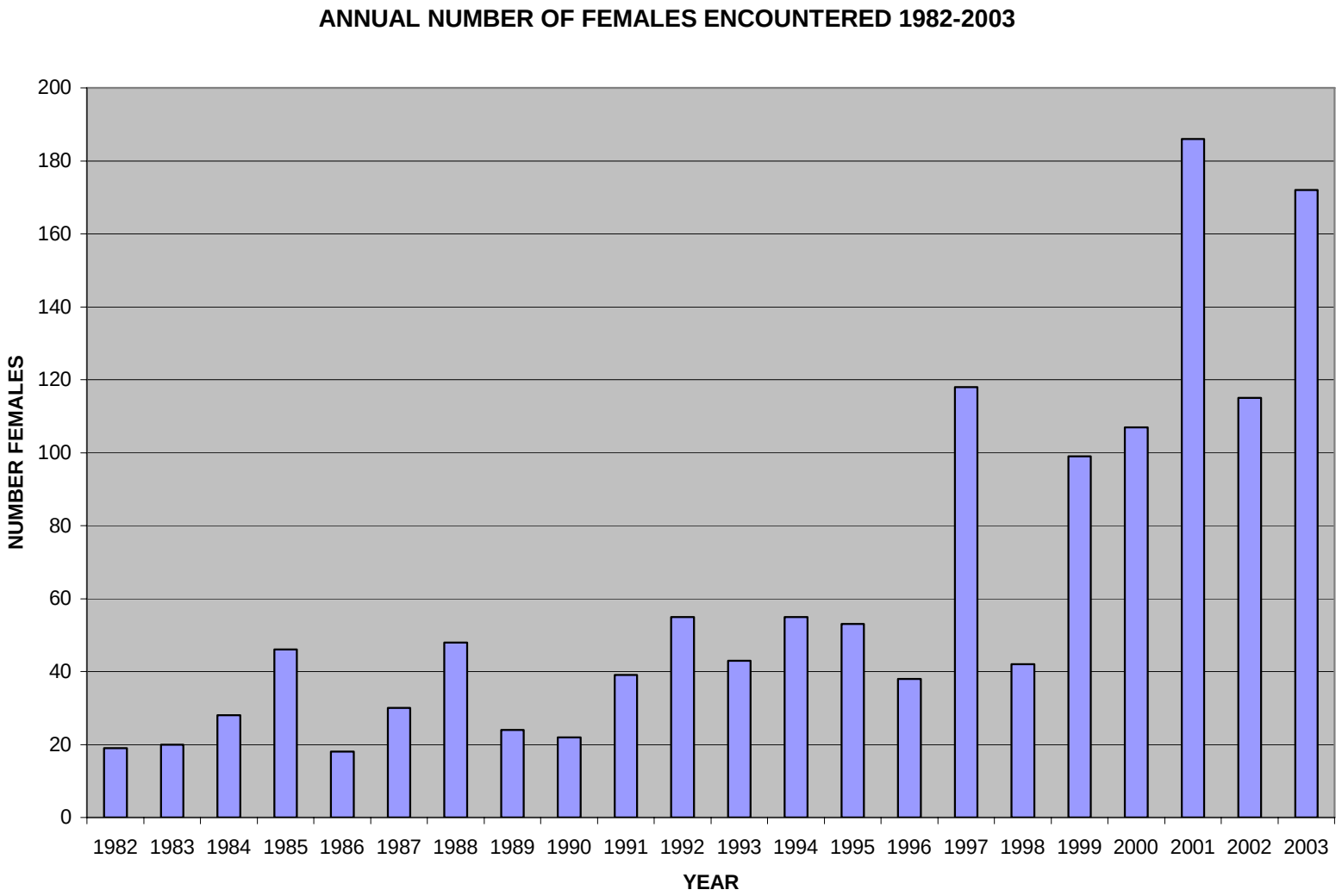

Figure 2. Graph showing the annual number of nesting turtles encountered from 1982 through 2003 nesting seasons.

Table I. Leatherback remigrations to Sandy Point from 1977 to 2003 (population not monitored 1978 and 1980).

Season	Total Turtles Encountered	Remigration Interval						Tag Scarred	Total Remigrant
		1	2	3	4	5	>5		
1977	10	0	0	0	0	0	0	0	0
1979	6	0	0	0	0	0	0	0	0
1981	20	0	3	0	0	0	0	0	3 (15.0%)[3]
1982	19	0	0	0	0	0	0	1	1 (5.3%)[3]
1983	20	0	7	0	0	0	0	2	9 (45.0%)
1984	28	0	4	0	0	0	0	0	4 (14.3%)
1985	46	1	10	3	0	0	0	2	16 (34.8%)
1986	18	0	1	2	0	0	0	0	3 (16.7%)
1987	30	0	9	5	0	0	0	0	14 (48.3%)
1988	48	0	5	7	1	0	0	4	17 (35.4%)
1989	24	0	7	0	0	0	0	0	7 (29.2%)
1990	22	0	2	3	1	0	0	0	6 (27.3%)
1991	39	0	8	8	0	0	0	14	16 (41.0%)
1992	55	0	6	4	7	0	0	44	17 (30.9%)
1993	43	0	13	4	0	0	0	74	17 (39.5%)
1994	55	0	14	8	1	1	0	144	24 (43.6%)
1995	53	0	16	7	5	0	0	N/A[5]	28 (52.8%)
1996	38	0	13	5	4	2	0	N/A[5]	24 (63.2%)
1997	118	0	27	22	5	3	0	N/A[5]	57 (48.3%)
1998	42	0	15	6	3	1	0	N/A[5]	25 (59.5%)
1999	99	1	32	9	4	2	26	N/A[5]	50 (50.5%)
2000	107	0	10	28	2	3	2	N/A[5]	45 (42.1%)
2001	186	1	45	12	26	1	27	N/A[5]	96 (51.6%)[8]
2002	115	1	35	23	5	3	1	N/A[5]	70 (60.9%)[9]
2003	172	0	84	12	6	3	3	N/A[5]	114(66.3%)[10]
Totals		4	366	168	70	19	59	35+[5]	

1 Does not represent total number of turtles nesting.
2 May or may not represent total number of turtles nesting.
3 Not accurate due to incomplete tagging in previous years; proportions in later years are more accurate but still not complete.
4 We do not include tag-scarred turtles in the count of remigrants, as we cannot determine if they were tagged at Sandy Point.
5 Photoidentification and PIT tags have identified many tag-scarred turtles as remigrants.

6 7 year remigration interval
7 1 six year, 1 nine year remigration interval
8 9 turtles were originally tagged in Puerto Rico; we have no information on remigration intervals
9 2 of the 3 turtles that were originally tagged in Puerto Rico; we have no information on remigration intervals
10 2 unidentified, previously tagged turtles, we have no information on remigrations intervals, additionally we have no information on the remigration intervals of the 4 turtles originally tagged in Puerto Rico

ranged from 100.3 to 123.0 cm, with an average width of 112.7cm ± 4.42 cm. Size class distribution among new and remigrant turtles is depicted in Figure 3. The average size (length and width) of the 2003 nesting population is consistent with that of the population in past years.

The average number of nests laid per individual female ranged from 0-10, with an average number of 5.4 ± 2.44 nests laid per female during the 2003 nesting season. Four turtles were documented as never successfully completing a nest on Sandy Point, while some nests, such as those laid prior to April 1 were deposited by unidentified turtles. In addition to early season nests, probable lays, and nesting on beaches other than Sandy point result in an underestimate of the number of nests laid per turtle. As an alternative method of determining the average number of nests laid per turtle, the number of total nesting activities (974) may be divided by the number of individual turtles (172). The average number of nests laid, when calculated in this manner, is also 5.7. This is consistent with the 2002 and 2001 nesting season which averaged 5.1 and 5.4 nests/turtle respectively, as well as previous nesting seasons.

The average number of dry runs per adult was also determined for the 2003 nesting season. A dry run is defined as an unsuccessful attempt at egg deposition. A dry run is not a track only, and must consist of the turtle attempting to body pit, and/or dig a nest cavity before returning to the water. There were 317 documented dry runs during the 2003 nesting season, with the number of dry runs per turtle ranging from 0 to 27. The average number of dry runs was 1.7 ± 2.85 per turtle. This is similar to the 2002 season when there was an average 1.8 ± 3.01 dry runs per turtle. One turtle in particular, a remigrant (AAB 421), exhibited a pattern of consistent dry runs, with a total of 27 dry runs during the season.

Inconel tags were applied to all turtles without flipper tags. This includes those that were not previously tagged, as well as turtles that had been previously tagged, but lost their tags. We also removed tags that were damaged or detaching, and retagged the turtles. As a result, 98 flipper tags were applied this season, with all 58 new turtles tagged. PIT tags were also applied to the new turtles, as well as remigrant turtles, as needed. Many remigrant turtles had detectable pit tags, but were tagged with AVID encrypted PIT tags only readable by AVID scanners. Therefore, unencrypted “Focava” code PIT tags, readable by scanners from various manufacturers, were additionally applied to the opposite shoulder of remigrants with only one PIT tag. As a result, 112 PIT tags were applied to both new and remigrant turtles during the 2003 season. Of the 58 new turtles in 2003, 56 were PIT tagged, with only 2 new turtles left without PIT tags.

Saturation tagging at Sandy Point almost makes the need for pink spot photos obsolete. This fact, along with time restrictions on the beach resulted in a decreased need and ability to obtain pink spot photos in 2003. However, 11 pink spot photos were taken including 10 new turtles and 1 turtle from Culebra. There were also 24 wound photos taken of 7 injured turtles, including 3 new, 2 remigrant turtles, 1 unidentified turtle, and 1 turtle from Culebra. Of these documented injuries, 50% involved the shoulders, 18.8% involved the head and neck, 12.5% included the carapace, an additional 12.5% included

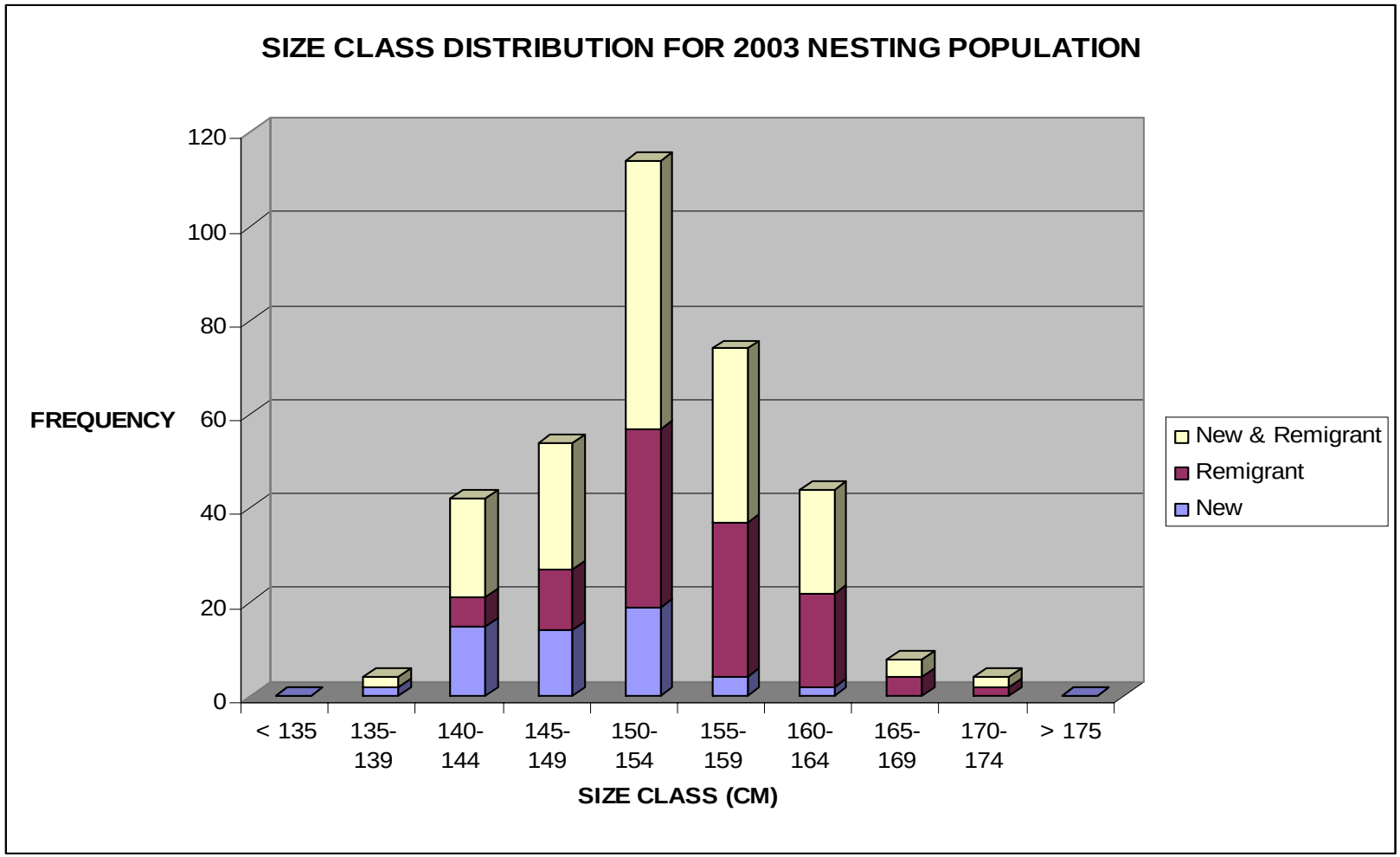

Figure 3. Size class distribution of nesting leatherbacks for the 2003 season.

the flippers and 6.3% affected the thigh. Figure 4 illustrates recorded injuries and frequency. Turtles with major wounds, not including lesser injuries documented on other turtles throughout the season, accounted for 4% of the 2003 nesting population. This is dramatically lower than the 2002 nesting population which had fewer turtles (115) and a larger percentage of the population injured (32%). Injuries appeared to be caused by interactions with boats, fishing tackle, nets, ropes and lines.

All ectobiota was documented throughout the season and as in past years three main types of barnacles were found. These included the *Stomatolepas dermochelys, Conchoderma sp.,* and *Platylepas hexastylos.* Barnacles were found primarily attached to the shoulders, neck, carapace and wounds of adult leatherback turtles. The fish *Remora remora* was encountered attached to 5 turtles in 2003. This number is greater than the 2 turtles with remora observed in 2002, but fewer than in 2001, when at least 8 turtles with remora were observed.

Blood and skin samples were collected for genetic analysis. Blood samples were collected from 88 turtles (including 40 neophytes) while 58 skin samples were collected (including samples from 18 neophytes). Plasma samples were also collected for further analysis of physiological parameters. Genetic analysis is currently being conducted by Dr. Peter Dutton at the NOAA-NMFS Southwest Science Center's La Jolla Laboratory.

Nesting Activities

During the period of monitoring (April 1 – September 1, 2002) a total of 1458 activities were recorded at Sandy Point. This number is higher than any of the previous seasons, but is closest to the 2001 season which boasted 1,289 activities, and had a more similar number of turtles. The first nest was recorded on February 21st (Mike Evans and Claudia Lombard, USFWS). The early season nesting activities were numerous (88), and greater than any of the previous seasons in project history. Known egg deposition occurred in 67% (974) of the nesting activities, while 22% (317) of all activities were dry runs. Only 6% (86) of the activities were probable lays, with another 6% (81) of the activities recorded as track only. Of the 974 known nests deposited on the beach this season, 66% (644) were *in situ*, while 34% (330) were relocated. Of the 330 nests which were relocated this year, it is estimated that 100% of them would have been lost to erosion or inundation had they not been removed and relocated to a different area of the beach.

Figure 5 represents the breakdown of turtle activity during each week of the study period, starting April 1st. Peak activity occurred during the month of May, with the greatest activity recorded during the weeks of May 6th and May 27th. No turtles were observed on April 17th, and again at the end of the season starting July 6th. The last activity, a probable lay, was recorded on August 10th.

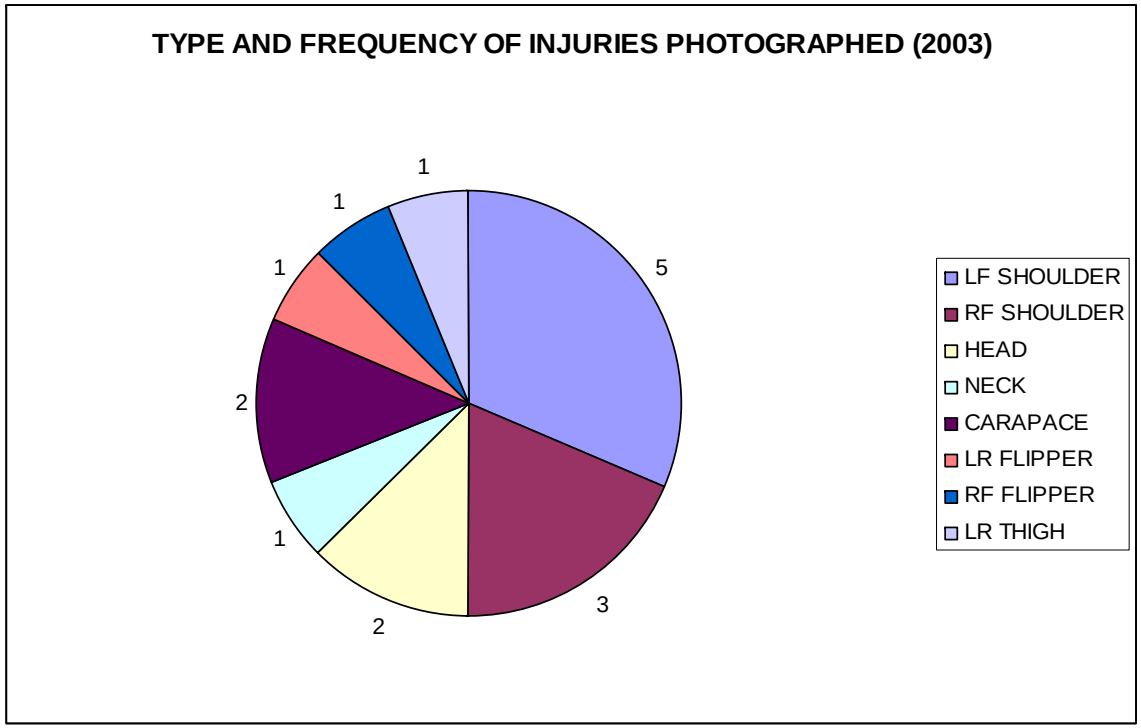

Figure 4. Number and proportion of injuries occurring on leatherbacks in 2003. Injuries are divided according to section of the body.

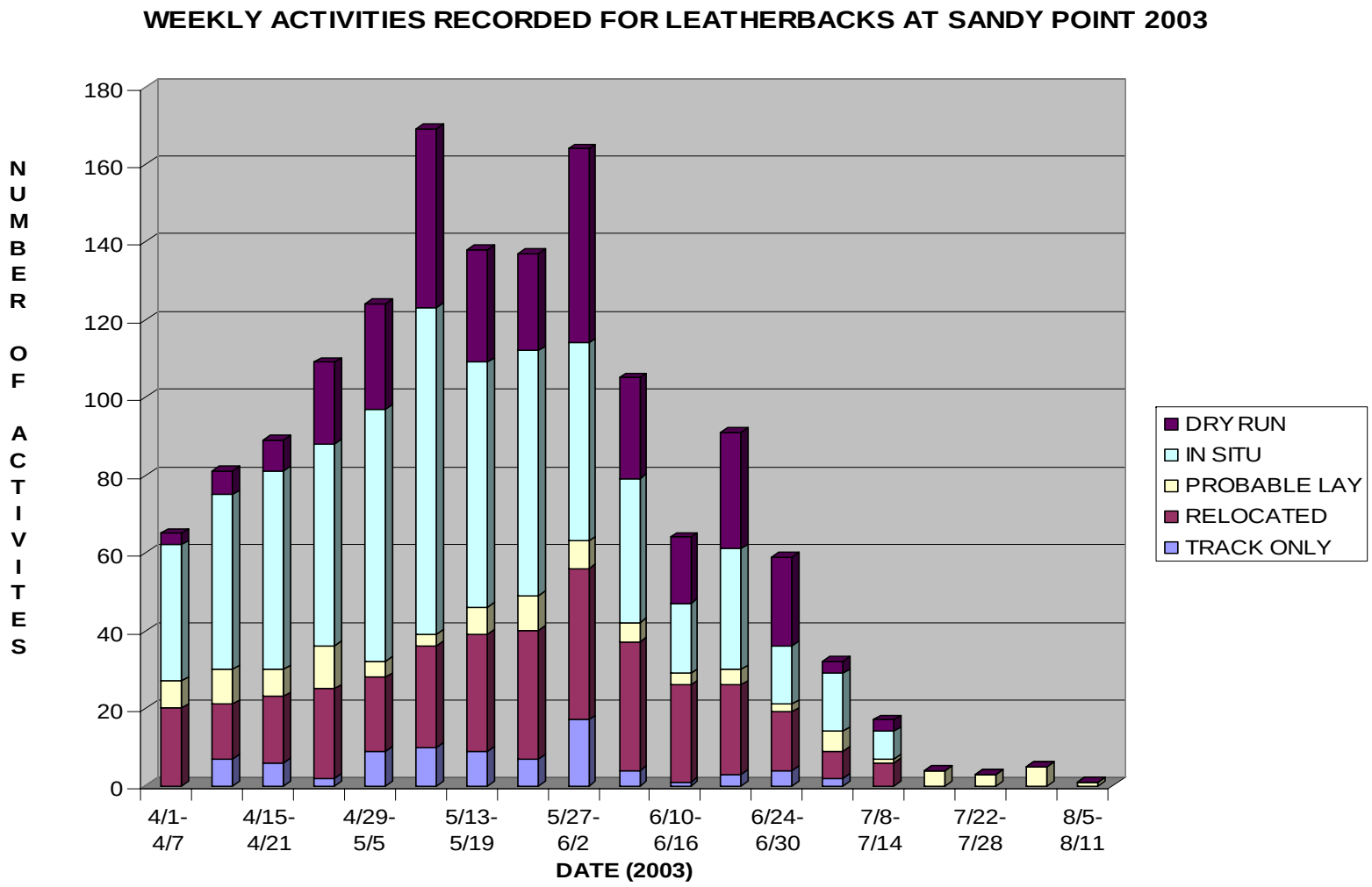

Figure 5. Graph showing the activities of leatherback on the beach by week from the 1st of April to the 11th of August 2003. The activities recorded are; dry run, in situ nests, probably lays, relocated nests, and tracks only.

In order to illustrate the distribution of activities on the beach, the monitored area at Sandy point was divided into 5 sections. The grassy side was divided into 2 sections, from stake 66 to the entrance at 123 and from stake 124 to the point (stake 140). The sandy side was divided into 3 sections, with section 1 starting from stake 141 around the point, and encompassing the entire erosion zone to stake 169. The remaining 2 sections include the accretion zone, from stake 170 to the entrance at stake 186, as well as from stake 187 to stake 200 at the end of the patrol area. The distribution of nesting activities within these given areas (Figures 6 and 7), shows that a majority of the *in situ* nests, 38%, were laid in the accretion zone from stakes 170 to 186, while 13% were laid on the grassy side between stakes 66 and 123. The erosion zone was the section of the beach where most dry runs (48%) occurred, while 28% of dry runs occurred in the accretion zone between stakes 170 and 186 on the sandy side. Another 13% of the dry runs occurred on the grassy side between stakes 56 and 123. Stakes 123 to 140 on the grassy side (to the point) had very little activity of any kind.

Beach use by leatherbacks during the 2003 nesting season was similar to the 2002 nesting season. There was, however, a slight increase (from 10% to 23%) in the use of the Northern section of the beach from 187-200. A concurrent decrease (from 47% to 38%) in beach use occurred from stakes 170-186. Use of the grassy side was also slightly lower (from 29% to14%) during the 2003 season. The overall use of the beach remained the same as in 2002, with most nest activities occurring in the accretion zone and a smaller percentage of activities occurring on the grassy side. The erosion zone continued to remain the area with the greatest number of dry runs, followed by the accretion zone.

The concentration of relocated nests on various sections of the beach are also illustrated (Figure 8), with 9% of the nests relocated in the upper level of the erosion zone during the early part of the season (until May 1), and another 8% relocated on the grassy side throughout the season. As in past seasons a majority of the nests were relocated in a designated zone on the sandy side which extended from the 200's South to stake 170 at the beginning of the accretion zone. As a result, 62% of the nests were relocated between stakes 170 and 186, with another 21% relocated between stakes 187 and 198.

A total of 98 nests were documented in the area designated for the no trample zone, with 48 laid *in situ* and another 50 relocated to this area. Of the total 346 *in situ* nests, as well as the 86 potential nests, 38 were considered marginal and left. Of the known marginal nests, at least 4 emerged. It is estimated that at least 15 washed away. An additional 4 marginal nests were found in the process of being washed away. The eggs were collected and incubated with excellent success. With 11 complete nests documented as washouts, 3% of the nests were definitely lost due to erosion. However, since it is likely that more nests washed out than were documented, it is estimated that 4% of the nests were lost due to erosion. This is similar to previous years.

The number of yolked eggs per clutch varied from 15 to 133, with a mean of 79.9 ± 19.8 eggs. This is slightly higher than the 2002 season when the mean number of eggs laid was 75.4 ± 1.09, and is similar to 2001 when the mean number of yolked eggs was 81.6 ± 16.85 eggs. The number of yolkless eggs varied from 0 to 98, with a mean of 35.8 ± 16.6 yolkless eggs. This is similar to the 2002 and 2001 seasons which had an average of 37.6 ± 1.00 and 35.64 ± 16.78 yolkless eggs respectively. Accurate counts of the

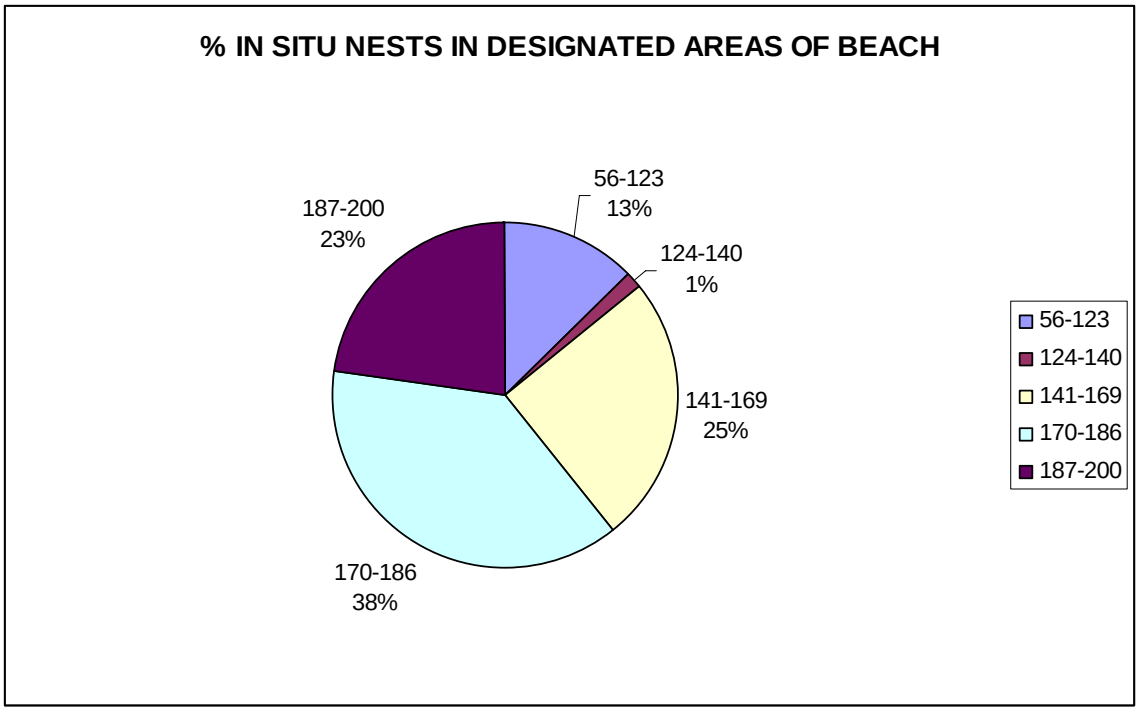

Figure 6. Percent of nests left naturally in different sections of the beach. Beach is divided into sections according to numbered stakes.

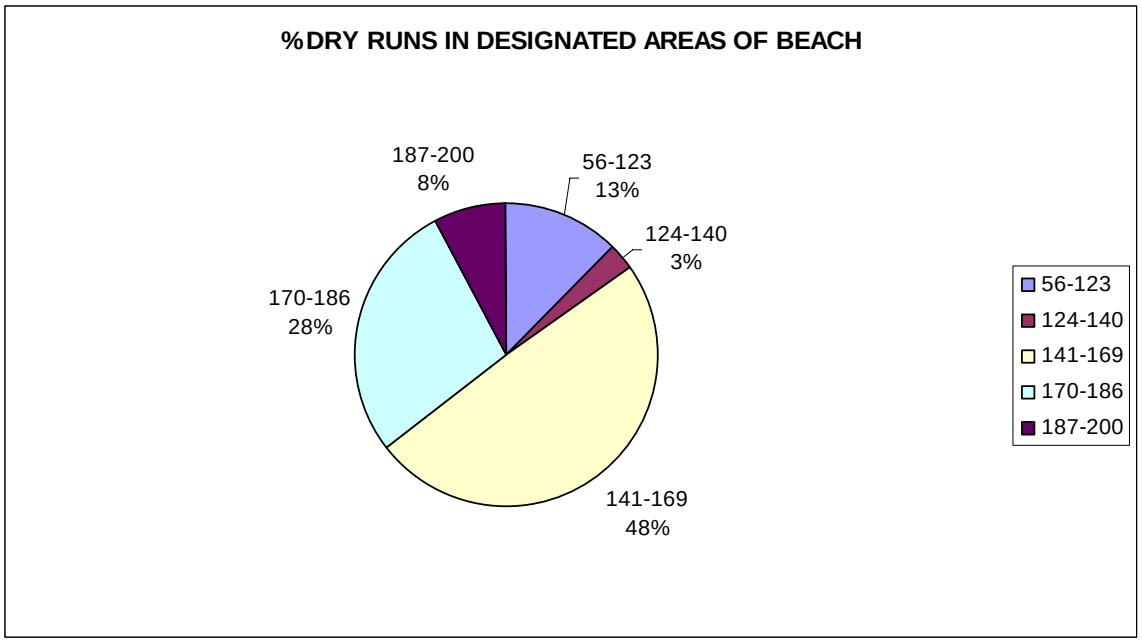

Figure 7. Percent of dry runs occurring in different sections of the beach. Beach is divided into sections according to numbered stakes.

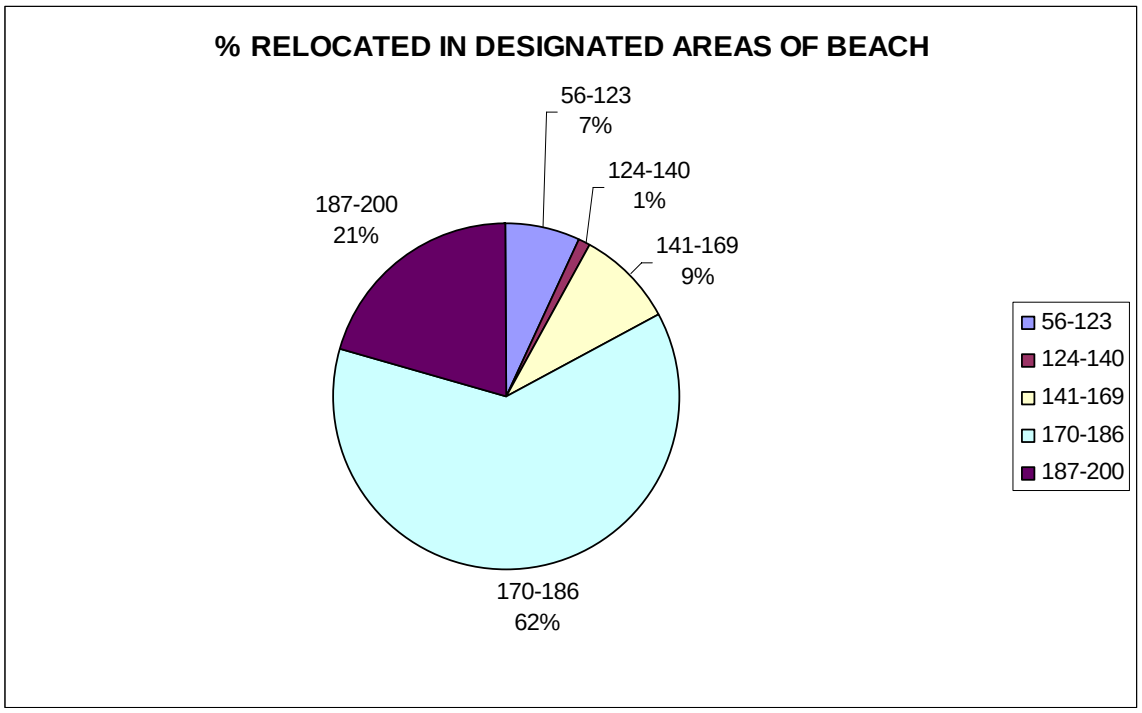

Figure 8. Percent of nests relocated to different sections of the beach. Beach sections are divided according to numbered stakes.

number of yolked and yolkless eggs were obtained by utilizing information solely from the relocated nests.

Hatchlings

The incubation period for nests throughout the season ranged from 57 to 70 days with an average incubation period of 60.1 ± 6.43 days. This is similar to the 2002 season which had an average incubation period of 62.4 ± 2.99 days, as well as the 2001 season which had an incubation of 63.8 days.

Of nests excavated during the 2003 season, 440 were utilized to determine hatch and emergence success. Fifty four percent of the relocated and 50% of the *in situ* nests were excavated. Mean overall hatch success (hatched shells/yolked eggs) of all excavated nests ranged from 0 to 100%, with a mean of 59.6 ± 23.38%. This is up from 2002 when mean overall hatch success was 53.05 ± 23.35%, and is more similar to the 2001 season which had 58.81 ± 19.62% hatch success. Actual mean emergence success (hatched shells-dead hatchlings/yolked eggs) was 56.7 ± 23.29% (n = 440, range = 0 – 100%). This is higher than the 2002 season which had 50.01 ± 22.99%, and is more similar to the 2001 season which had 55.22 ± 19.52%. Hatch success was significantly lower ($p<0.01$, t-test) in relocated nests (50.42 ± 21.73%, n = 167, range = 0 to 100%), than in known *in situ* nests (65.09 ± 22.63%, n =273, range = 0 to 100%). Corresponding mean emergence success was 47.82 ± 21.48 and 62.12 ± 22.72% ($p< 0.01$, t-test) (Table 2). Most of the mortality in both relocated and *in situ* nests was due to hatchlings dying during pipping, or shortly after. Using the average emergence success (known nests only) of 47.82% and 62.12% for relocated and *in situ* nests, respectively, it is estimated that 43,282 hatchlings emerged at Sandy Point in 2003 (Figure 9). This takes into account an estimated 4% (26 nests) that may have washed away. Relocated nests produced 29 % of total.

Aberrations

In the 440 nests utilized to determine hatch success, 55 deformities were found including 13 hatchlings and 42 in unhatched eggs. The majority of deformities were found to be abnormal shaped heads and eyes, twins, albinos, and cyclopses. Six particular turtles produced deformities in more than one nest.

No Trample Zone

There were 58 nests successfully excavated in the area of the beach designated as the no trample zone, while 31 nests were excavated in the trample zone of the beach. The overall hatch and emergence success of the nests in the no trample zone were slightly higher than the trample zone. The hatch success of the no trample zone was 60.14 ± 22.88%, with a mean emergence success of 56.14 ± 22.75%. The mean hatch success of the trample zone was 53.79 ± 29.41%, with a mean emergence success of 51.01 ±28.93%. The slight difference between the no and high traffic areas was, however, not significant (t-test, $p>0.1$, DF=55).

Table 2. Final outcome of leatherback nests on Sandy Point from 1982 to 2002.

Year	Known				Not excavated	Total
	Survive to term		Lost			
	N	% hatch success ()	erosion	poaching		
2003						
relocated	167	50.4	0	0		
in situ	273	65.1	11	0		
unknown[7]	50					
total	490	59.5	11	0	484	974
2002	145	46.9	0	0		237
relocated						
in situ	201	57.5	8	0		346
Unknown[7]	28					
total	374	53.1	8	0	209	583
2001			0	0		
relocated	61	54.3				
in situ	165	60.8	0	0		276
unknown[7]	68		30	0		732
total	294	58.8	30	0	684	1008
2000						
relocated	151	53.7	1	0	9	161
in situ	290	64.1	26	0	71	387
total	441	60.6	27	0	80	548
1999						
relocated	100	56.6	0	0	51	151
in situ	250	61.4	27	0	152	429
total	350	60.1	27	0	203	580
1998						
relocated	44	36.9	0	0	18	
in situ	117	46.8	4	0	72	251
total	161	44.1	4	0	90 (36%)[6]	
1997						
relocated	126	46.9	0	0	112	
in situ	178	53	23	0	281	
total	304	50.4	23	0	393 (55%)[6]	720
1996						

relocated	57	57.4	2	0	11	
in situ	103	68.6	6	0	61	
total	160	64.5	8	0	72 (30%)[5]	240
1995						
relocated	67	52.4	0	0	52	
boxes	17	66.2	0	0	0	
in situ	45	64	6	0	138	
total	129	57.9	6(1.8%)	0	190 (58%)	325
1994						
relocated	99	60.6	0	0	35	
in situ	107	66.8	12	0	102	
total	206	63.8	12(3.4%)	0	137 (39%)[4]	355
1993						
relocated	81	64.5	0	0	11	92
in situ	122	69.3	6	0	44	172
total	203	67.4	6(2.3%)[1]	0	55 (21%)[2]	264
1992						
relocated	123	61.3		0	22	145
in situ	108	72.2	21	0	71	200
total	231	66.3	21(6.1%)	0	93 (27%)[3]	345
1991						
relocated	99	62	0	0	10	109
in situ	122	72.3	13	0	16	151
total	221	67.8	13(5.0%)	0	26 (10%)	260
1990						
relocated	54	61.1	0	0	0	54
in situ	75	70.5	1	0	13	89
total	129	66.7	1(0.7%)	0	13 (9.1%)	143
1989						
relocated	72	63	0	0	2	74
in situ	49	76.4	4	0	10	63
total	121	67.8	4(2.9%)	0	12 (8.8%)	137
1988						
relocated	141	58.53	1	0	3	145
in situ	89	56.86	3	0	5	97
total	230	58.23	4(1.7%)	0	8 (3.31%)	242
1987						
relocated	91	62.78	3	0	1	95
in situ	63	67.41	3	0	10	76
total	154	66.55	6 (3.5%)	0	11 (6.4%)	171

1986						
relocated	30	68.97	2	0	5	37
in situ	25	64.61	6	0	14	45
total	55	66.79	8 (9.8%)	0	19 (23.1%)	82
1985						
relocated	110	53.2	1	1	8	120
in situ	90	62.8	16	2	14	122
total	200	57.6	17 (7.0%)	3 (1.2%)	22 (9.1%)	242
1984						
relocated	82	54.8	0	0	6	88
in situ	41	67.7	7	1	4	53
total	123	59.1	7 (4.9%)	1 (0.7%)	10 (7.1%)	141
1983						
relocated	69	50.5	3	0	5	77
in situ	28	64.4	6	2	0	36
total	97	54.5	9 (7.9%)	2 (1.8%)	5 (4.4%)	113
1982						
relocated	23	64.4	1	0	3	27
in situ	22	61.4	25	0	12	59
total	45	62.9	26(30.2%)	0 (0.0%)	15 (17.4%)	86

[1] This number may have been higher, since early season activities recorded as "dry runs" may actually have been nests that subsequently washed away; these would not have been recorded as nests since there was no evidence of emergence.

[2] 33 of these nests emerged (22 *in situ*, 11 relocated), as evidenced by hatchling tracks, but were not excavated. This number includes three nests that were not excavated prior to our departure.

[3] Most of these nests emerged, as evidenced by hatchling tracks. This number includes 17 nests that were not excavated prior to our departure.

[4] At least 60 of these nests emerged (52 *in situ*, 8 relocated). Thirteen nests had not emerged prior to our departure.

[5] Includes nests for which there was some success, but some eggs were washed out.

[6] A large portion of these hatched.

[7] Due to extremely high nest densities in 2001, some of the excavated nests could not be identified to female.

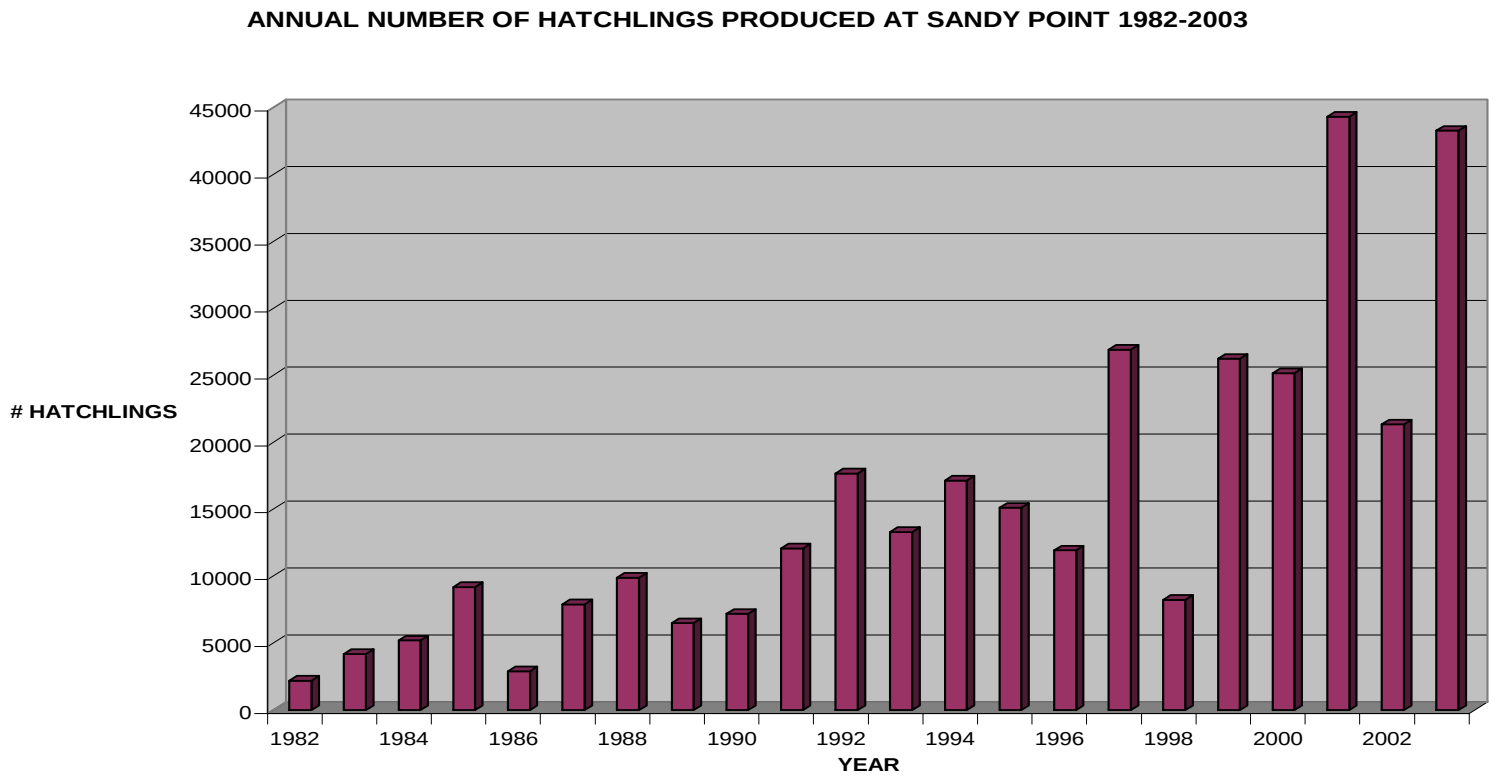

Figure 9. Graph of the number of hatchlings produced by year from 1982 to 2003.

Mortality

There was one fatality documented during the 2003 nesting season. An adult male leatherback was attacked by numerous tiger sharks and killed in the waters off Sandy Point. The incident was witnessed by a fisherman who towed the remaining carcass to shore, where it was photographed and then removed by the U.S. Fish and Wildlife Service.

Eggs

As in past years the major threat to eggs on Sandy Point continues to be erosion. The seasonal beach erosion on Sandy Point follows a distinctive pattern, which results in the loss of an entire stretch of beach from the point (Stake 140) through to stake 170. Since a majority of nests are laid in this zone, the relocation effort prevents the loss of 30-65% of nests annually. In 2003, 34% of known nests were relocated, thus preventing the loss of a large percentage of nests and reducing nest loss to less than 4%, as in past seasons.

Although poaching was considered a problem at Sandy Point prior to the induction of the program, and the presence of Refuge personnel, it is no longer a serious threat to leatherback eggs. There was no evidence of poaching during the 2003 nesting season. There were also no attempts during the 2002 and 2001 seasons. Overall, the frequency of poaching attempts has dropped dramatically since 1985, to virtually no attempts on the refuge property.

Hatchlings

During the 2003 season, the most significant terrestrial predators of leatherback hatchlings at Sandy Point were feral dogs, cats, yellow-crowned night herons (*Nyctanassa violacea*) and ghost crabs (*Ocypode quadrata*). This is similar to past years' results. The mongoose (*Herpestes aropunctatus*) has been an increasing problem, and its presence was documented on the beach again this season. Trapping by U.S. Fish and Wildlife personnel reduced the threat of mongoose predation. A more serious and increasing threat, however, is the presence of feral cats and dogs on the beach. Cats were documented numerous times this year patrolling the vegetation line for emerging hatchlings, as well as actually taking hatchlings, even in the presence of large groups of people. There was also evidence of cats digging into nests and taking hatchlings before they had a chance to emerge. This threat was first noticed during the 2001 season, and appears to have increased significantly during the 2002 and 2003 seasons. Although there was little or no evidence of canine predation during the past two seasons, dogs have historically been a problem at Sandy Point, and this problem resurfaced in 2003. A large pack of up to 8 dogs routinely patrolled the beach during hatchling season, destroying innumerable nests.

Beach vegetation poses a threat of entanglement to emerging hatchlings, as well as to eggs and hatchlings in the nest cavity. The roots of various species of beach vines, such as (*Opmea, Canavalia,* and *Cassythe filiformis*) may infiltrate the nest cavity, and/or sprawl across the sand surface trapping hatchlings in the nest cavity, as well as on the

surface as they attempt to journey to the water. Failure of eggs to successfully develop is also observed when eggs are subjected to root growth in the nest cavity.

A few nests this season showed fatalities when some hatchlings remained on the surface too long and either died of dehydration or attack by fire ants. Ants appeared to be a greater problem on the grassy side of the beach, where vegetation is thicker, than on the sandy side.

Other Turtle Species

Greens

There were only two green activities observed by research personnel during the 2003 season, including 1 dry run by a neophyte and 1 probable lay from an unidentified turtle.

Hawksbills

The first hawksbill activity recorded during the 2003 season was May 17th. There were a total of 27 activities observed including 8 dry runs, 7 successful nests, 5 probable lays, and 7 tracks. No nests were relocated in 2003.

There were a total of 10 turtles, including 6 new and 4 remigrant turtles. Flipper tags were applied to all new turtles. Some turtles were tagged twice, resulting in the application of 8 flipper tags. Four PIT tags were also applied to new turtles.

The lengths of recorded hawksbill turtles ranged from 82.8 cm to 94.4 cm, with an average length of 88.50 ± 5.49 cm. The width of recorded hawksbills ranged from 67.5 cm to 85.9 cm, with an average width of 78.00 ± 8.75 cm.

Although the leatherback project ended September first, beach patrols were continued for green and hawksbill turtles at Sandy point after this time. This project was also supported by the U.S. Fish and Wildlife Service, Division of Refuges, and information on this green and hawksbill population study will be summarized by Amy Mackay in a separate report to Fish and Wildlife.

Mortality

The threats that are experienced by both the hatchlings and eggs of leatherback turtles are also threats that affect green and hawksbill hatchlings and eggs as well. The threat of poaching, however, is much greater for these two species. Although poaching of eggs is minimal while Sandy Point is patrolled nightly during leatherback season, once patrols stop, the threat increases dramatically. An additional threat to these species is the value of the adult. Adult green and hawksbill turtles are poached for their meat and shells, in addition to the eggs. Traditionally, both eggs and adults are taken after the leatherback season ends at Sandy Point, and year round throughout the rest of St. Croix. In 2003, however, there was no evidence of poaching on the refuge after the leatherback season ended. This is most likely due to the continuation of nightly patrols for green and hawksbill turtles by Amy Mackay and her research team.

DISCUSSION

The 2001 season still maintains the record for number of nesting leatherbacks at Sandy Point with 186 nesting females. The 2003 season provided the second highest number of nesting females with 172 individuals. This number is much greater than the previous year which only had 115 turtles, and easily surpasses the third greatest year on record which was 1997 when 117 individuals nested. The 2003 season extended from February 21st to August 10th. With the addition of 58 new animals in 2003, a total of 691 individuals have been tagged since 1977. This number likely overestimates the population size, since some untagged turtles are remigrants that lost their tags from previous years. This has been confirmed by PIT tag returns and photoidentification (McDonald and Dutton, 1996). However, this is a more accurate estimate than shown in previous years' reports of this project, as it takes into account the percentage of untagged individuals photoidentified as remigrants. Continued use of PIT tags and photoidentification will provide more accurate information on population size and remigration rates, and allow estimates of adult mortality to be made (Dutton *et al*., 2000 and in prep). As in past years, several turtles (three in 2002, four in 2003) originally tagged on different beaches in Puerto Rico nested at Sandy Point. This combined with results of genetic studies continues to suggest that St. Croix and Puerto Rico leatherbacks are part of a larger, regional population rather than two distinct groups. Additional information supporting this theory was provided during the 2003 season when a turtle originally tagged at Sandy Point, and nesting at Sandy Point also nested at Culebra. While nesting at Culebra Dr.'s Molly Lutcavage and Sam Sadove fitted this individual with a satellite transmitter. Information from the transmitter suggested the turtle was returning to Sandy Point after spending multiple nesting cycles at Culebra. The turtle did indeed return to Sandy Point and completed her nesting season there. This information also supports the theory that Sandy Point and Puerto Rico leatherbacks are part of a more regional population. This idea bears further investigation and a cooperative effort between researchers in St. Croix and Puerto Rico.

Hatch Rates

Like most past years, hatch success for relocated clutches was significantly lower than that of *in situ* nests. Data from 1992 suggested that nest design has a significant influence on hatch rate, and that the lowered hatch rates are avoided in nests where eggs are stacked into a slanting bowl (the "natural" design, Dutton *et al*., 1992). Relocated nests were constructed using this "natural" design as a guide. Both relocated and *in situ*, as well as overall hatch success were higher this year than last year. Overall hatch success was on par with the 2001 season. The increase in hatch success during the 2003 season may be due in part to natural fluctuation, but may also result from the increase in available nesting habitat. In 2003 the beach was wider, extended further North, and had a more gradual berm, thus allowing the turtles to utilize a greater area of fresh, regenerated, sandy beach. During 2002 there was a steep berm, and little or no available nesting habitat North into the 200's. The decreased density of nests in 2002 may also have resulted in a decrease in the amount of bacteria present in the sand from the previous

season, and thus healthier nesting habitat in 2003. The effects of nest density, properties of the sand, and bacterial load on hatch success bear further investigation in the future. This may help us better predict hatch success, as well as assist in finding innovative ways to increase it.

No Trample Experiment

Although the difference among hatch success in the trample and no trample areas of the beach were not significantly different, there was a 4.0% higher hatch success in the no traffic area. This is similar to the results found in 2002, when hatch success was found to be 3.5% higher in the no traffic area. The sample size for this experiment was greater in 2003 (58 nests) than in 2002 (22 nests). However, due to small sample size results of either study remain somewhat inconclusive, and the experiment should be repeated again in 2004. Until definitive answers may be obtained regarding the effect of high traffic and recreational beach usage on hatch success, it is recommended that the beach remain closed during the peak of the nesting and hatchling season.

Other Research

Blood samples taken from nesting females during past seasons are being used for genetic and endocrinological studies in order to learn more about population structure and reproductive physiology in leatherbacks. Genetic analyses using mitochondrial DNA and nuclear (microsatellites) markers are being conducted by Dr. Peter Dutton at the National Marine Fisheries Service in La Jolla, California. Preliminary results suggest that some of the new nesting females are offspring of at least two of the long-term remigrants (Dutton et al., *In press*).

Information from the dataloggers inserted into 18 nests will also be downloaded and analyzed by Dr. Peter Dutton. This preliminary information may provide valuable insight into the high mortality present in relocated nests.

Visiting scientists in 2003 included Scott Benson and Dr. Jim Harvey who visited the project with Dr. Peter Dutton. They tested the success of various forms of suction cup attachment on the leatherback carapace. The best, most durable method of attachment will be utilized in the future, in conjunction with transmitters, to provide invaluable information regarding leatherback behavior and migratory patterns.

Public Awareness and Education

The Public Education program was run by Amy Mackay under the auspices of the U.S. Fish and Wildlife Service. Visitors were limited almost exclusively to students and community groups. Lectures were presented to the visitors prior to entering the refuge, or observing the turtles. Visitors included school, community, and church groups. Numbers and compositions of groups may be obtained from either Amy Mackay, or Mike Evans, Refuge Manager, USFWS.

Management Recommendations

General management recommendations and priorities are described in McDonald-Dutton (1997). Further recommendations are outlined in previous reports (McDonald-Dutton et al., 1999, 2000). There has been a tenfold increase in the numbers of females nesting since the start of this project 23 years ago. Unfortunately, however, funding and personnel have not increased significantly and are unable to support the increasing population numbers. In order to maintain the same level of intensity as originally conceived for this project, it is important to have adequate funding and staff support. Continued involvement of USFWS personnel is highly recommended, since the problems related to lack of staff have been partially alleviated by the invaluable presence of USFWS personnel on the beach, and their assistance with patrols and the time-consuming nest relocation process.

In light of the continuing upward trend in numbers of nesting females, especially the tremendous increases shown in 2001 and 2003, it is recommended that the focus of the project continue to be saturation tagging and data collection of nesting females. This is important due to potential scientific breakthroughs which will result from the unique database that has been established from two decades of consistent monitoring and saturation tagging. This effort will only come to fruition if consistency is maintained. Adequate funding is required to support current personnel with future research, as well as to hire additional personnel to assist with future studies, tagging, and monitoring of an expanding population. In addition to continuing the present research objectives, additional research, as well as cooperation with outside scientists and the researchers in Puerto Rico is advised. Use of dataloggers, satellite tagging, evaluation of sand properties, and further projects to increase the body of knowledge regarding this species and the nesting beach are encouraged. This includes studies tailored to the effects and implications of an expanding population. Continuation of the survivorship, mortality, and injury studies are all important aspects that should not be ignored. The outcome of such studies may provide further insight into recommendations and procedures for future management of the growing population. It is currently recommended that doomed nests continue to be relocated, but not at the expense of tagging, data collection, and other innovative research projects.

CONCLUSIONS

The number of females nesting at Sandy Point has been increasing steadily since 1991, and showed dramatic increases in 1997, 1999, 2000, 2002, and particularly 2001 and 2003 (Figure 2). This trend is very encouraging, since the leatherback continues to decline globally at an alarming rate. Results from this project suggest that a long-term commitment of at least ten years is needed before the effects of recovery efforts can be measured. This project serves as a model for successful recovery efforts, and for answering questions about leatherback behavior, reproductive biology and physiology.

Our findings have profound management implications for this species; if it is true that adults return to their natal beaches then we should expect a continued increase in the nesting population at Sandy Point as the hatchlings saved over the years begin to mature. Results from genetic analysis supports this theory, as does the dramatic growth of the population in the last few years. One explanation for this increase could be that hatchlings released in the first years of the project are now maturing and returning to nest at Sandy Point. If so, the upward trend in the numbers of females nesting each year should continue. If it does, this suggests an age at maturity of 10 - 15 years for leatherbacks. Genetic studies (Dutton et al. 1999) have shown that the St. Croix population is genetically distinct from others in the Caribbean outside the immediate region of the U.S. Virgin Islands and Puerto Rico, and this is also consistent with the natal homing hypothesis. Further genetic work will determine whether new turtles that nest are the offspring of females tagged in previous years.

This intensive research and conservation effort would not have been possible without the assistance of 1,295 Earthwatch volunteers who over the past twenty-one years have contributed over 103,484 hours patrolling over 77,584 miles of beach. Continued commitment by the Earthwatch Institute and by the USVI Division of Fish and Wildlife will help protect the leatherback as well as add to our knowledge of its reproductive and population biology. This is essential to the evaluation and modification of recovery and management plans to ensure the survival of this endangered species.

ACKNOWLEDGMENTS

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